

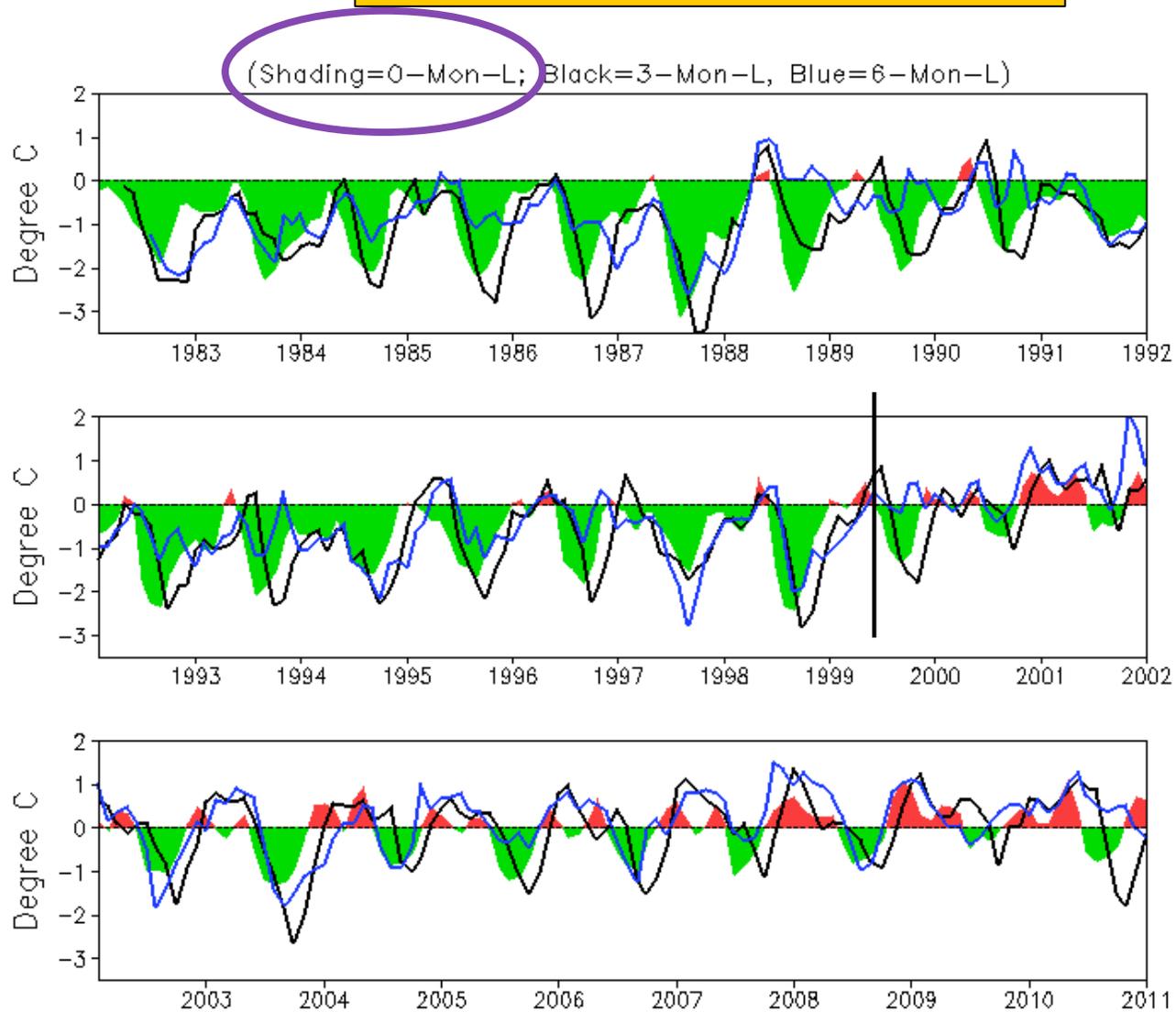
Tropical Pacific SST in CFSv2: Prediction Skill and Predictability

*Yan Xue, Mingyue Chen, Arun Kumar,
Zeng-Zhen Hu, Wanqiu Wang*

Climate Prediction Center
NCEP/NOAA, Maryland, U.S.A.

CFSv2 Evaluation Workshop, April 30 – May 1, 2012

Nino 3.4 SST: CFSv2 - OIv2



- Cold bias dominated before 1999, is largest during summer/fall

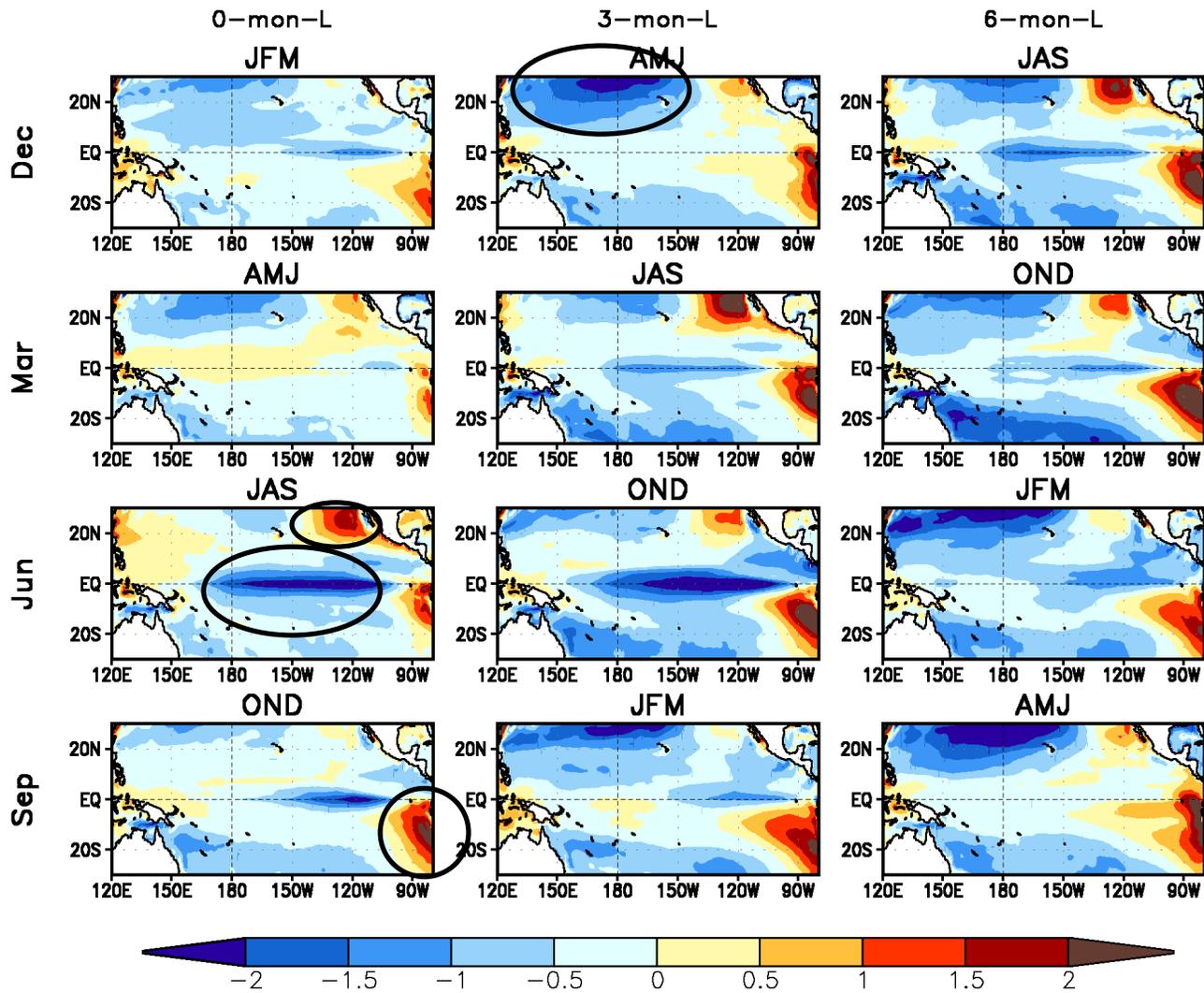
Outline

- **Model Data**
 - **9-month hindcasts, every 5th day and 4 times per day over 1982-2010**
 - **Lagged ensemble with 20 members**
 - **3-month-running mean SST**
- **Validation Data**
 - **OIv2 SST**
 - **R2 wind stress**
 - **EN3 heat content**
- **Forecast Biases**
 - **Forecast biases for each initial month and lead month**
 - **1982-1998 and 1999-2010**
 - **Ocean I.C. biases**

Outline

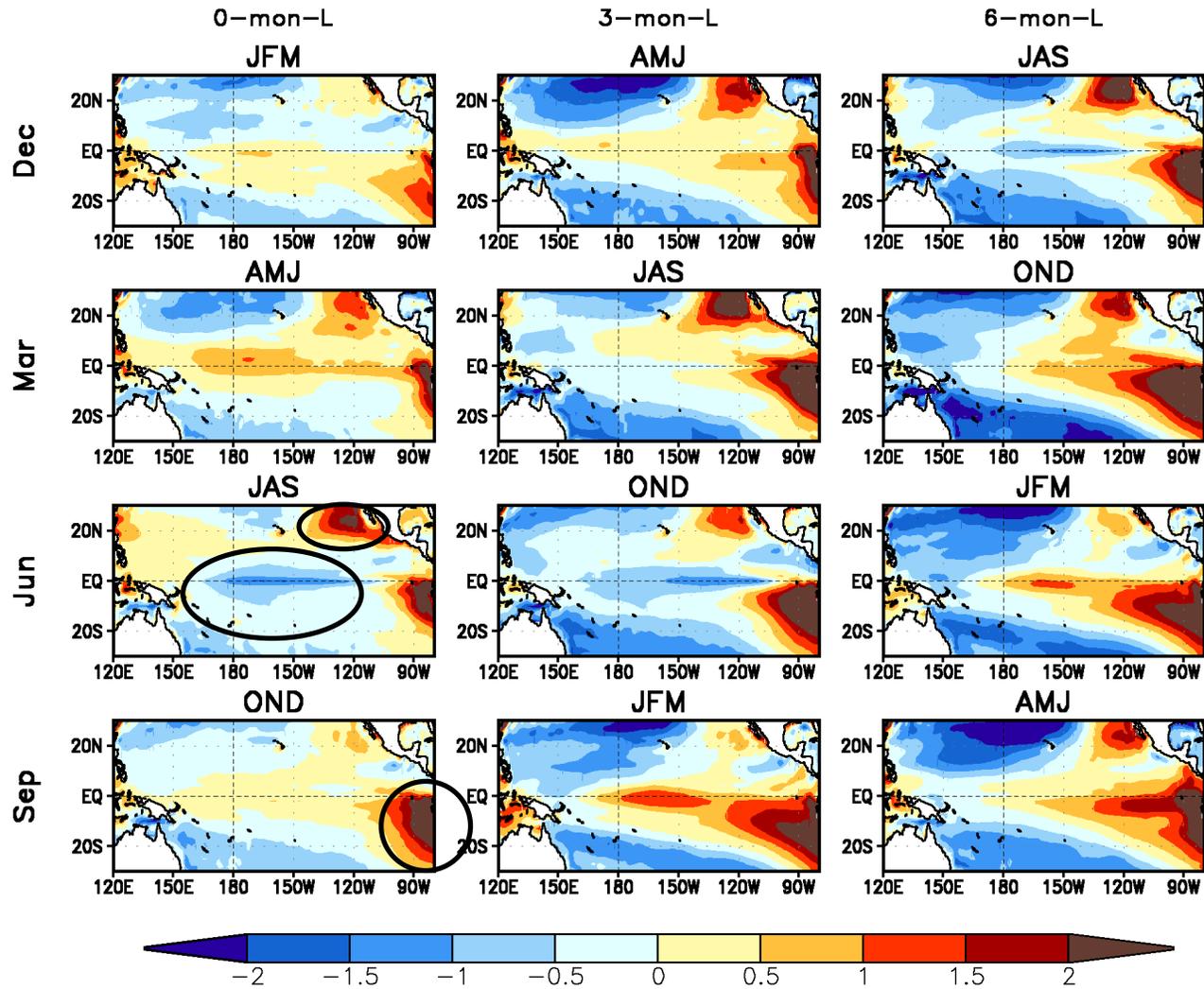
- **Interannual variability**
 - Standard deviation ratio
 - 1982-1998 and 1999-2010
- **Prediction skill and predictability**
 - Anomaly correlation, RMSE, Amplitude ratio
 - NINO3, NINO4, NINO3.4
 - 1982-1998 and 1999-2010
 - Perfect-model skill
 - Ensemble spread
- **El Nino composites**
 - NINO3, NINO4, NINO3.4
 - 1982-1998 and 1999-2010

SST bias 1982–1998 [K]



- Cold bias near the equator, subtropical N. Pacific
 - Warm bias in S.E. and N.E. Pacific.

SST bias 1999–2010 [K]

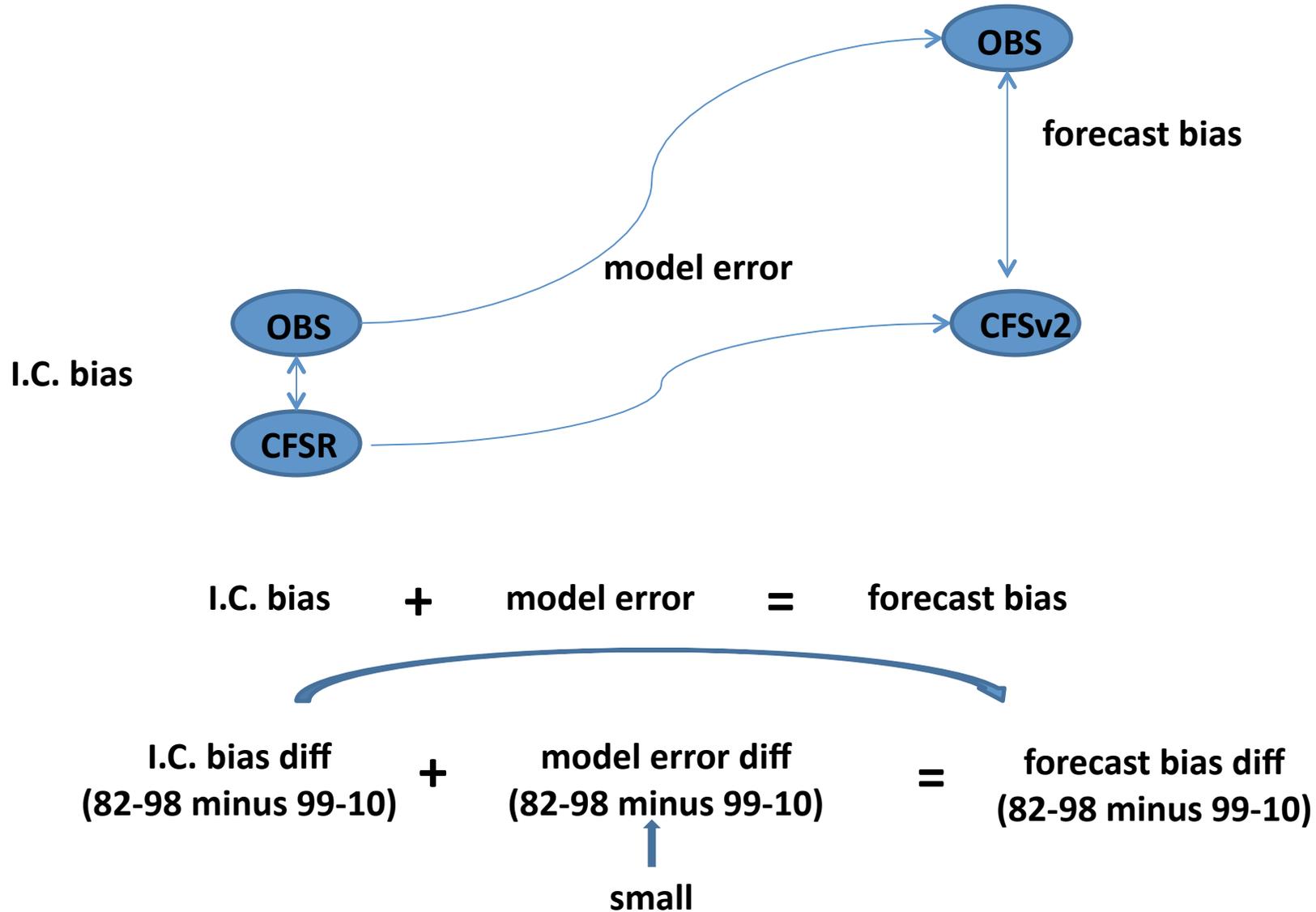


- Cold bias near the equator reduced significantly
- Warm bias in S.E. and N.E. Pacific enhanced

Why does SST Bias Differ in 1982-1998 and 1999-2010?

- There is a sudden increase in subsurface temperature in E. Pacific around 1998/1999 in CFSR, related to a sudden reduction of easterly wind biases (Xue et al. 2011)**
- The sudden shift around 1998/1999 is evident in many atmospheric fields (Wang et al. 2011; Chelliah et al. 2011; Ebisuzaki et al. 2011)**
- The shift is related to assimilation of ATOV satellite observations (Zhang et al. 2012)**
- The shift in subsurface temperature in E. Pacific attributes to a shift in SST forecast bias around 1998/99 (Kumar et al. 2012)**

Forecast Bias Diff. is Linked to I.C. Bias Diff.



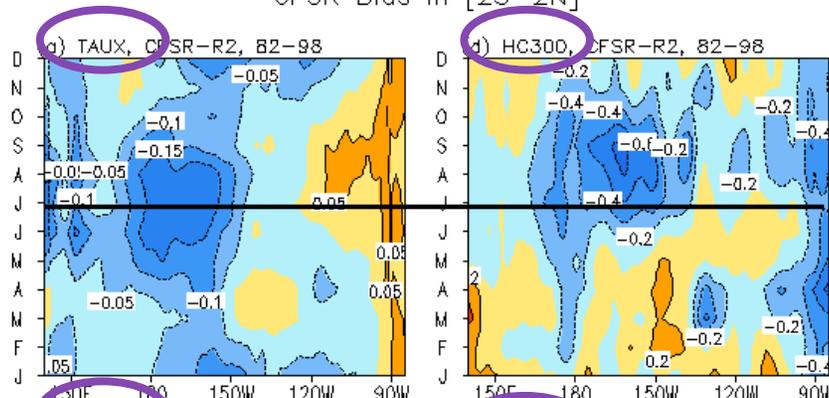
I.C. Bias in 2S-2N



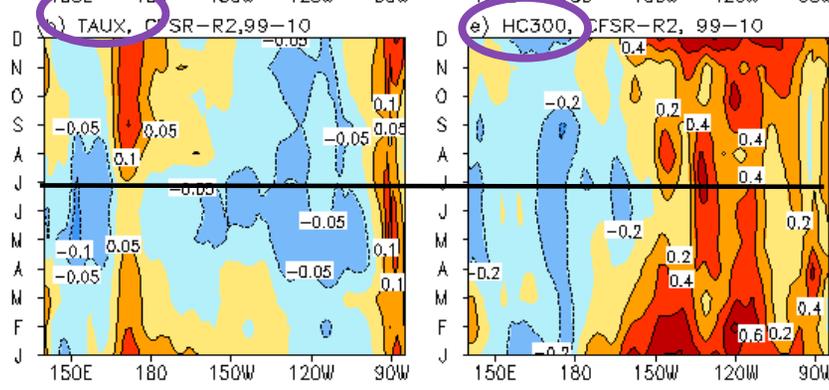
SST Bias

CFSR Bias in [2S-2N]

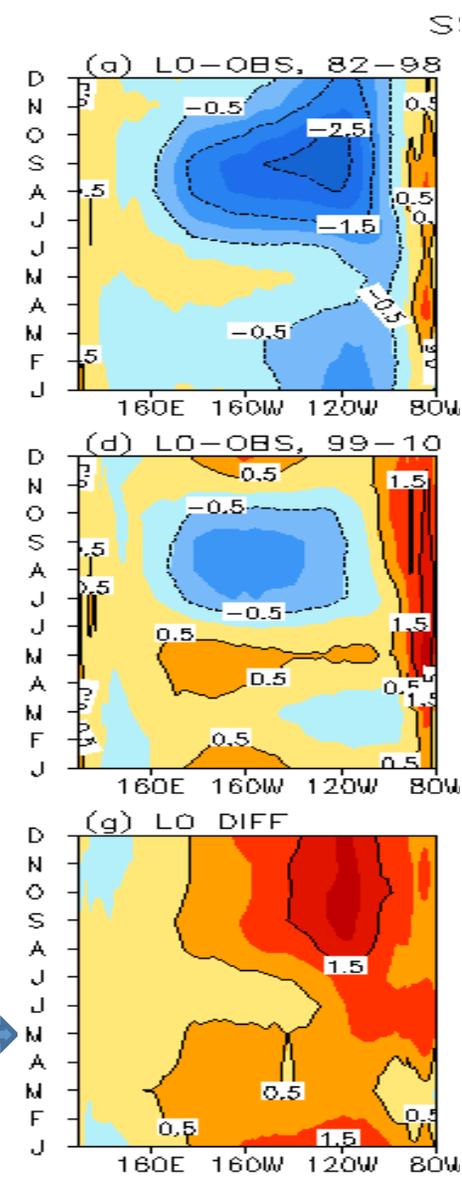
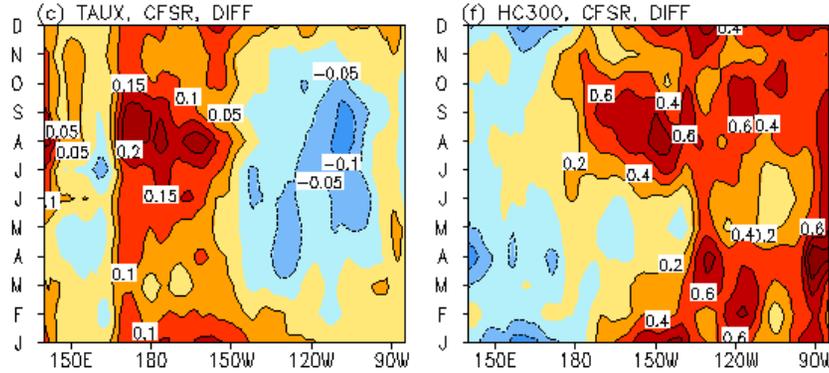
1982-1998



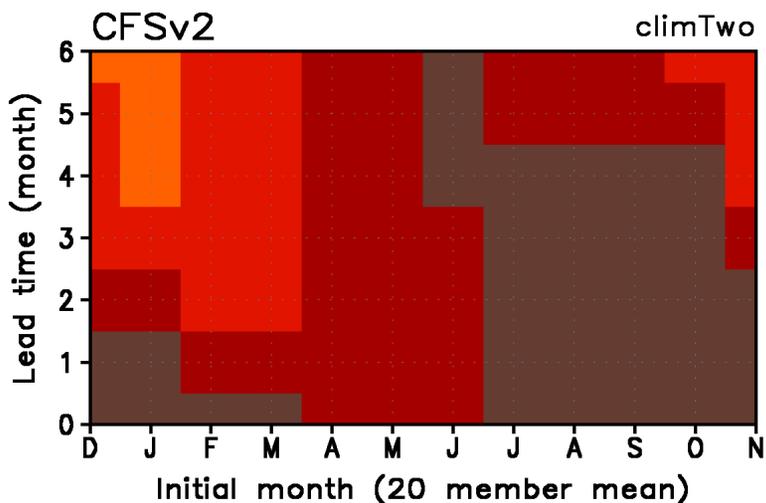
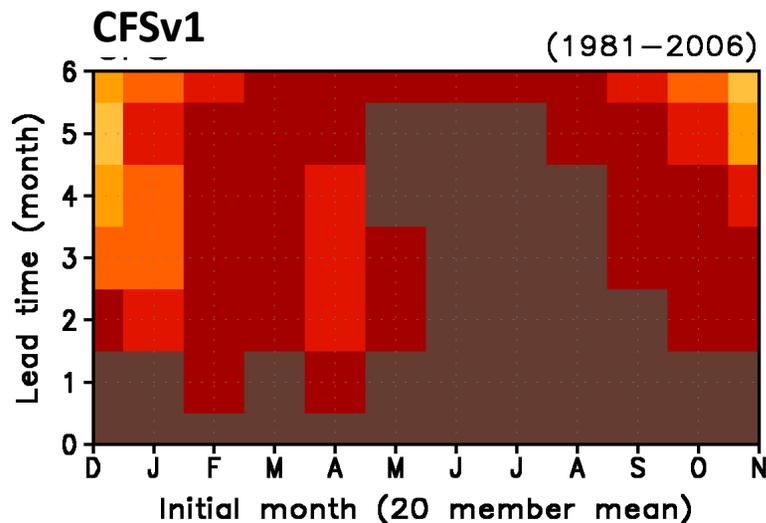
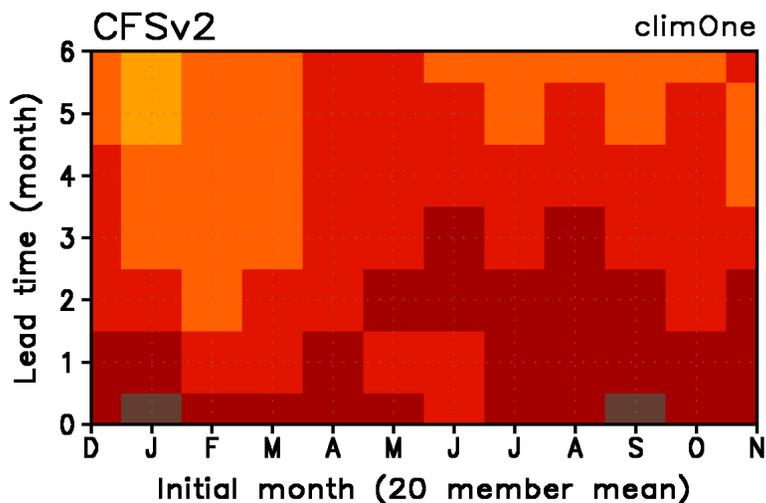
1999-2010



1999-2010 minus
1982-1998



Anomaly Correlation for Nino 3.4 SST Index



- CFSv2 is inferior to CFSv1 if systematic biases in 1982-2010 is removed

- CFSv2 is as skillful as CFSv1 if systematic biases in 1982-1998 and 1999-2010 are removed separately

- So we will analyze the skill in 1982-1998 and 1999-2010 separately in the following.

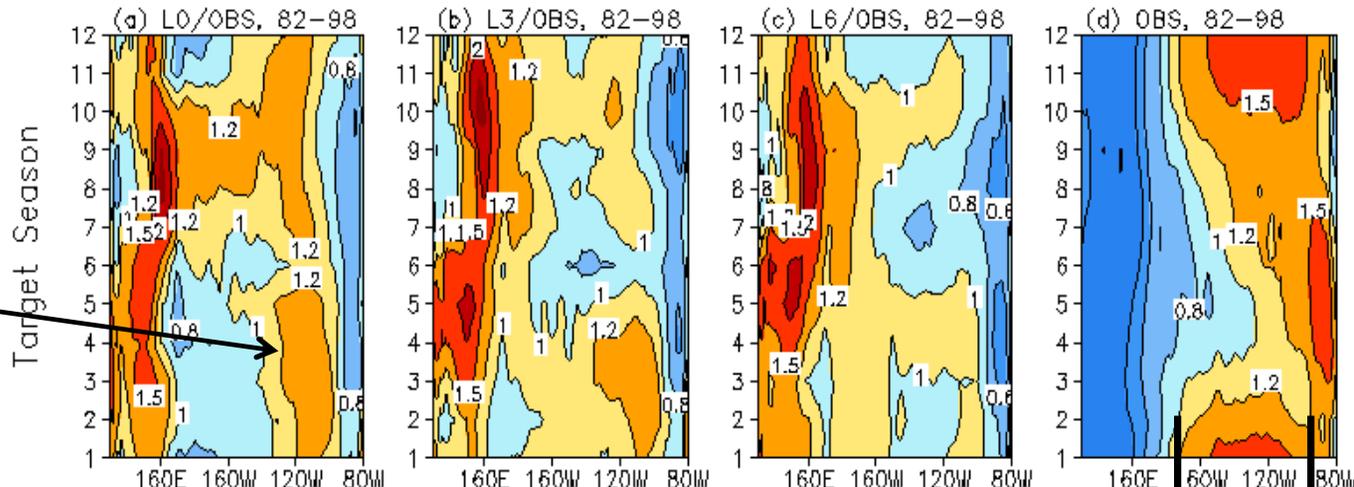
SST Standard Deviation Ratio in 2S-2N

0-mon-L 3-mon-L 6-mon-L OBS

Standard Deviation of SST in [2S-2N]

1982-1998

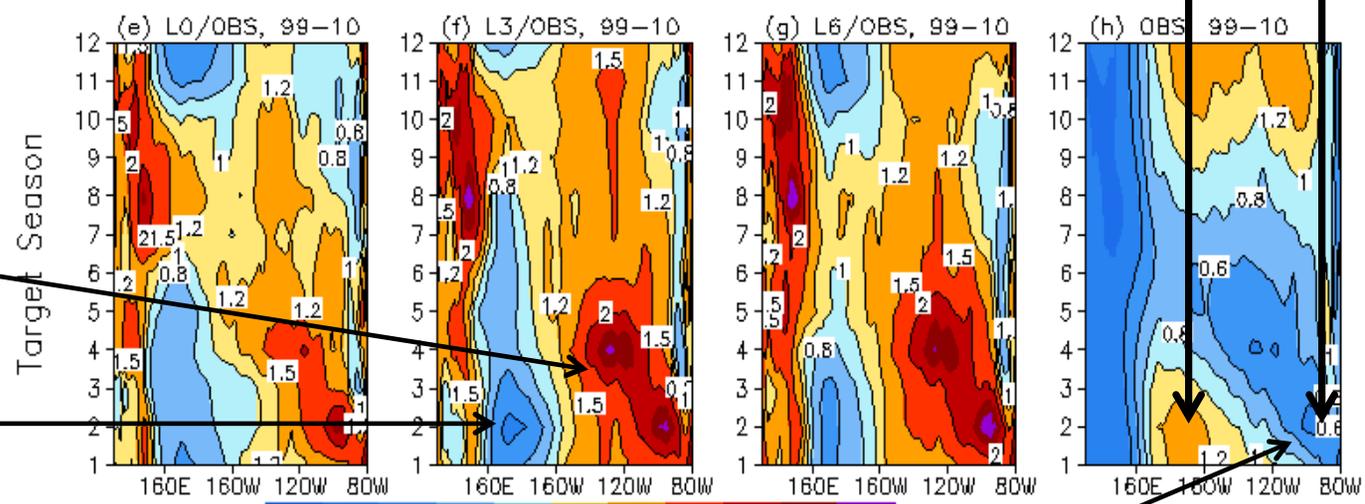
- STD is 20% too strong in E. Pac



1999-2010

- STD is 100% too strong in E. Pac

- STD is 40% too weak in W. Pac



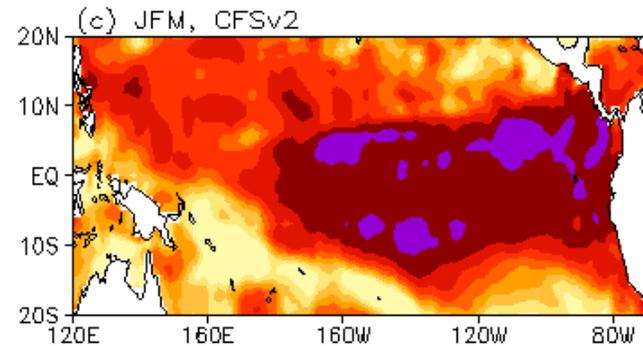
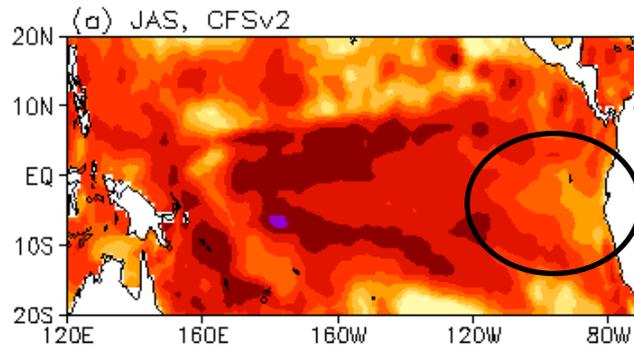
- STD in 99-10 is 40% of that in 82-98

3-Month-Lead Anomaly Correlation in 1982-1998

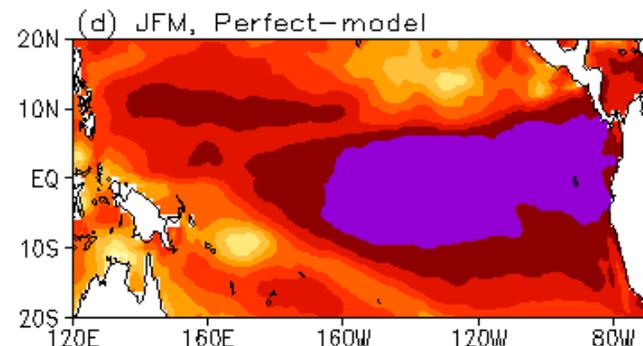
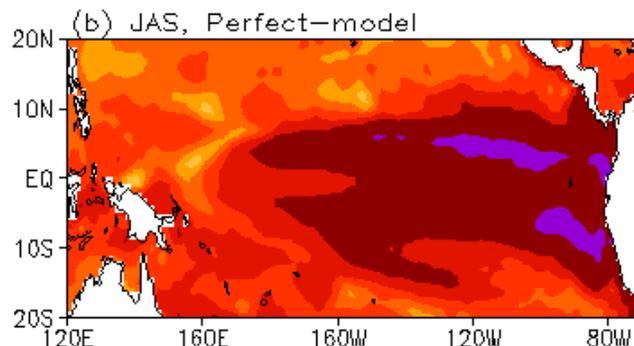
Jul-Aug-Sep

Dec-Jan-Feb

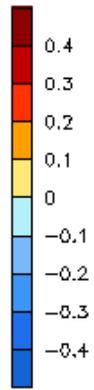
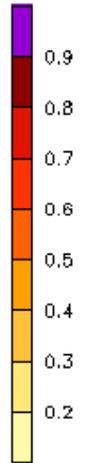
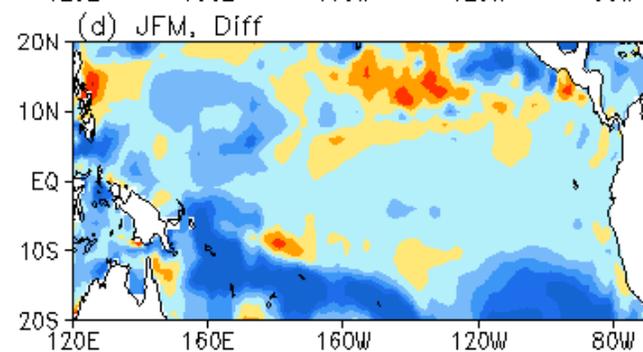
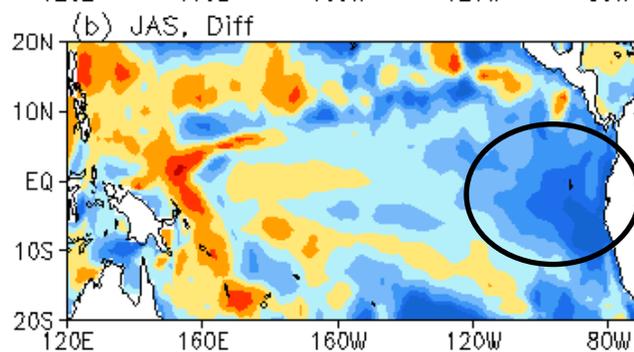
CFSv2



Perfect-model



CFSv2 minus
Perfect-model

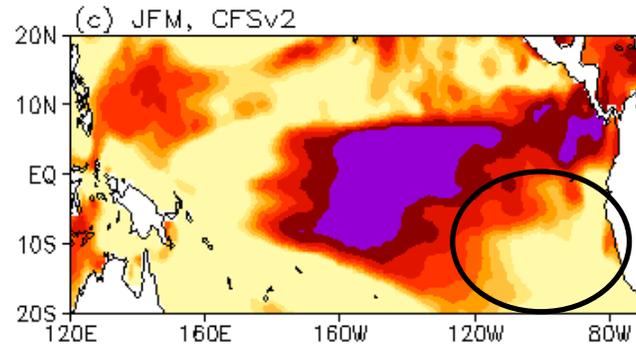
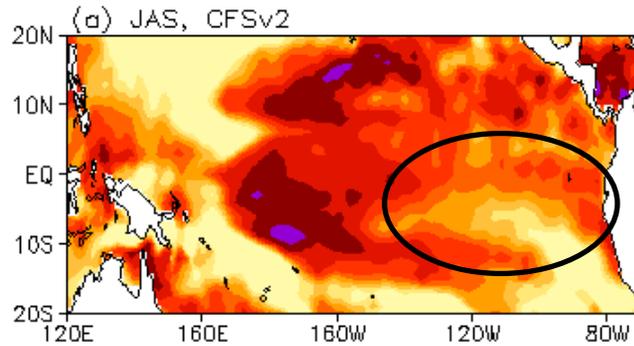


3-Month-Lead Anomaly Correlation in 1999-2010

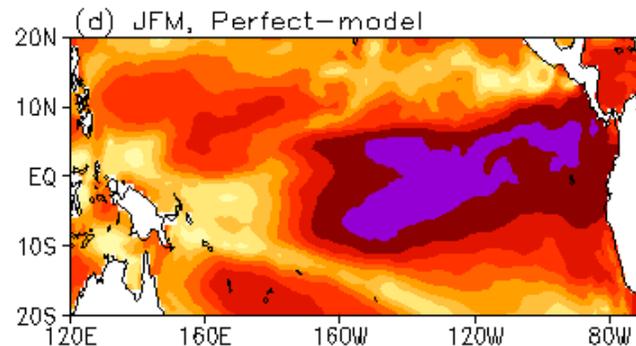
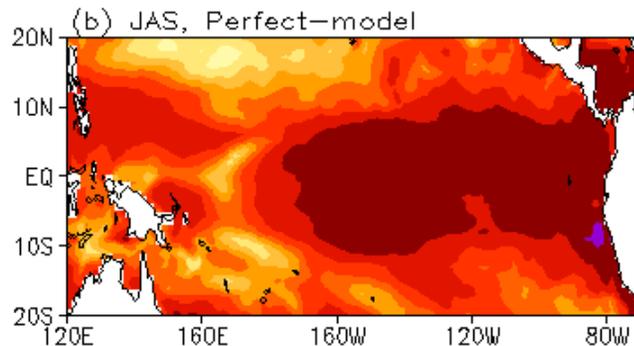
Jul-Aug-Sep

Dec-Jan-Feb

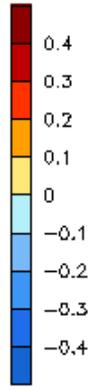
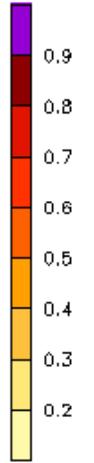
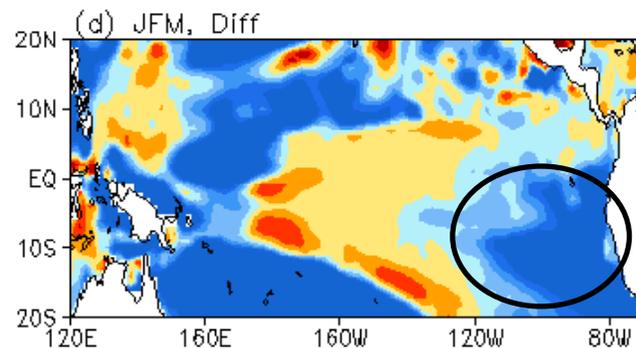
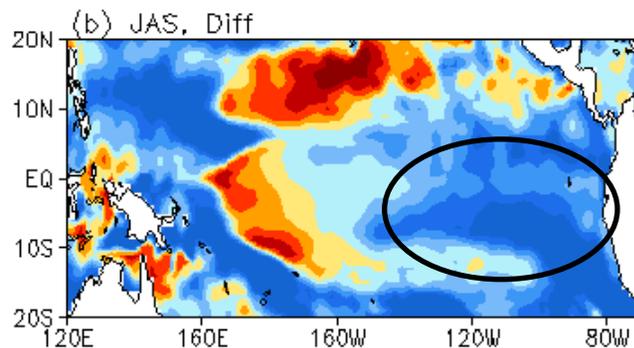
CFSv2



Perfect-model



CFSv2 minus
Perfect-model



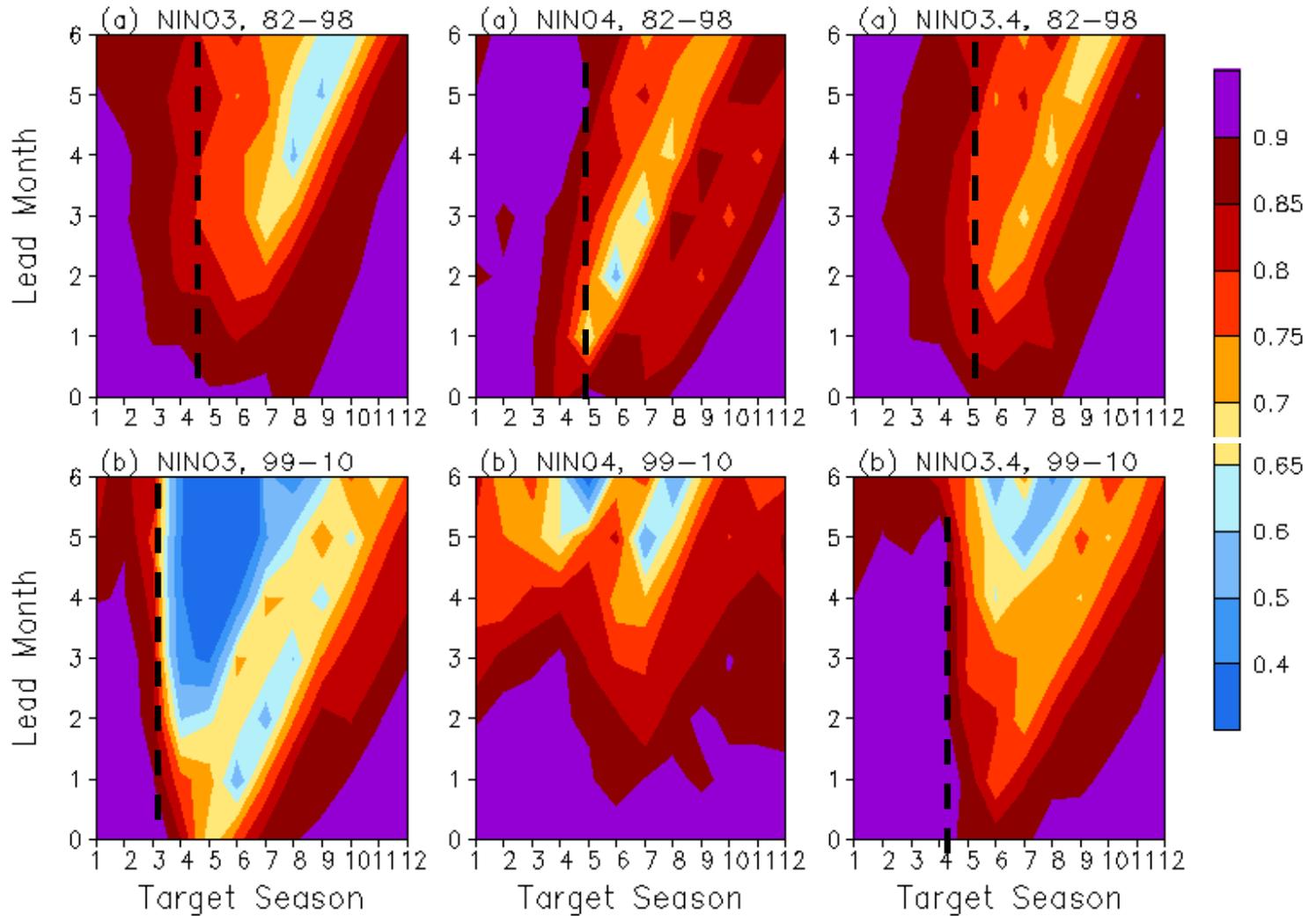
Anomaly Correlation for CFSv2 SST

NINO3

NINO4

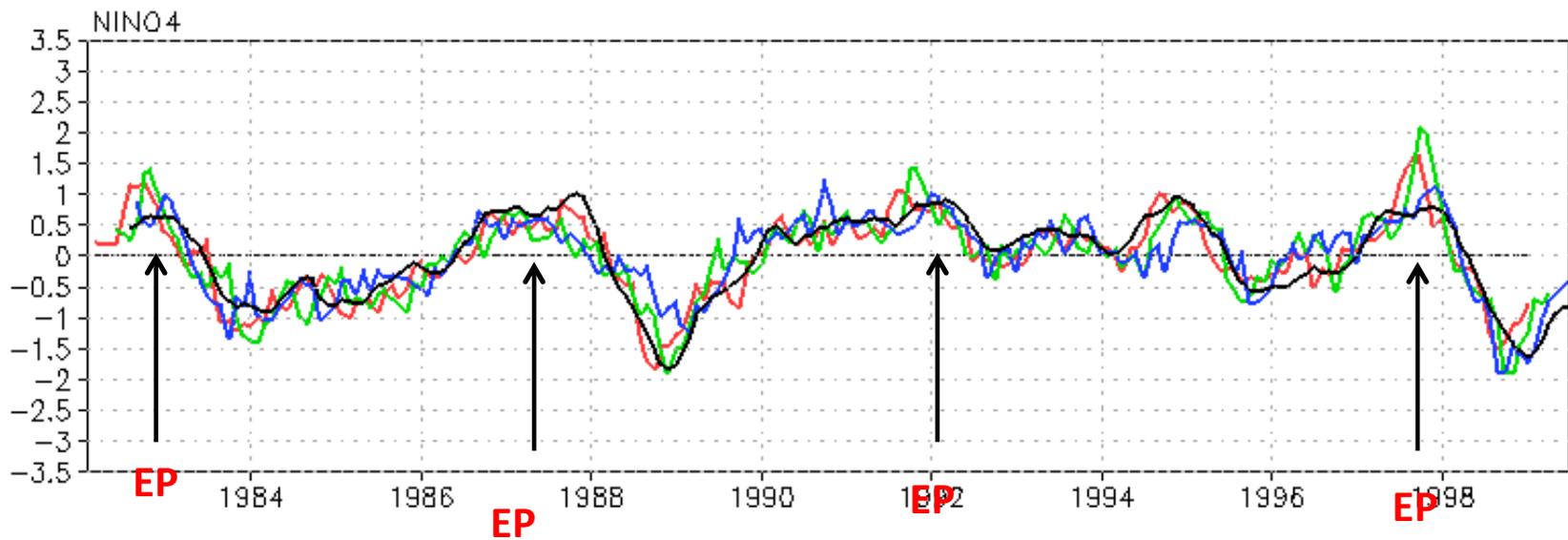
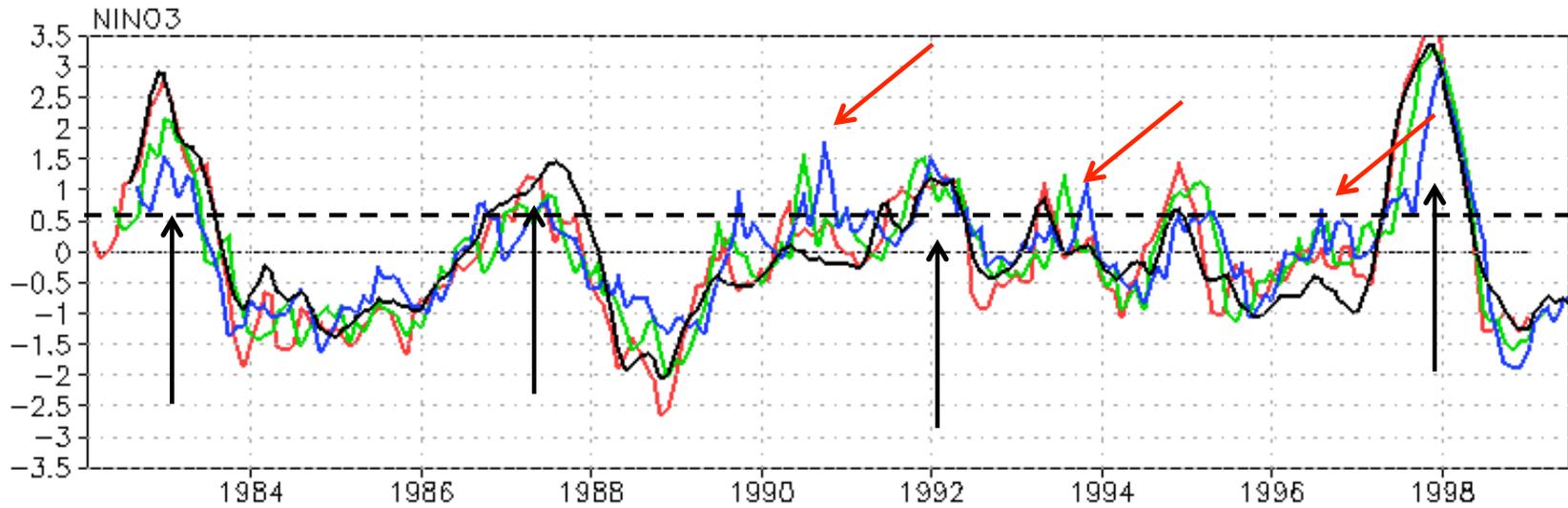
NINO3.4

1982-1998

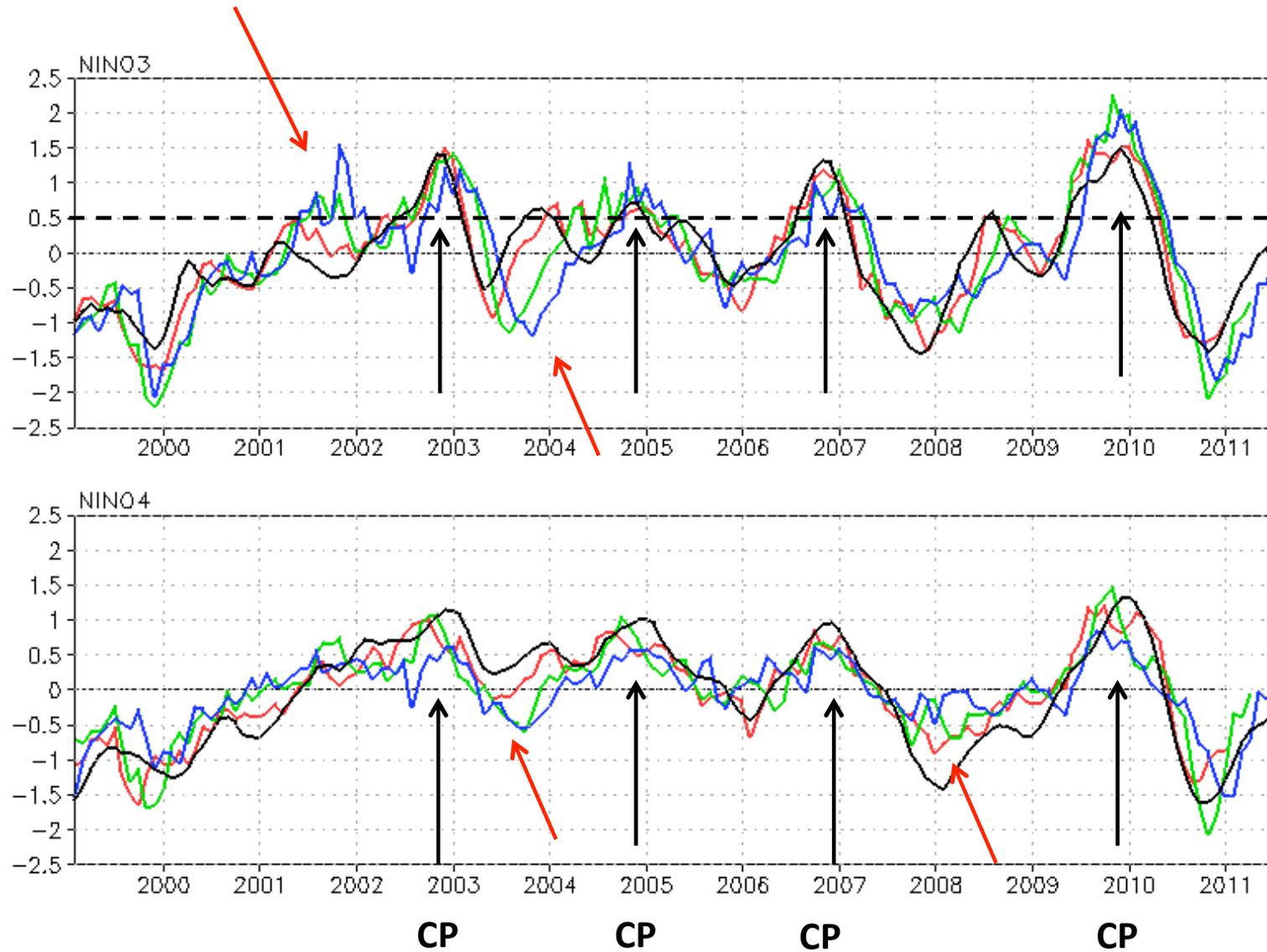


1999-2010

NINO3 and NINO4 in 82-98



NINO3 and NINO4 in 99-10



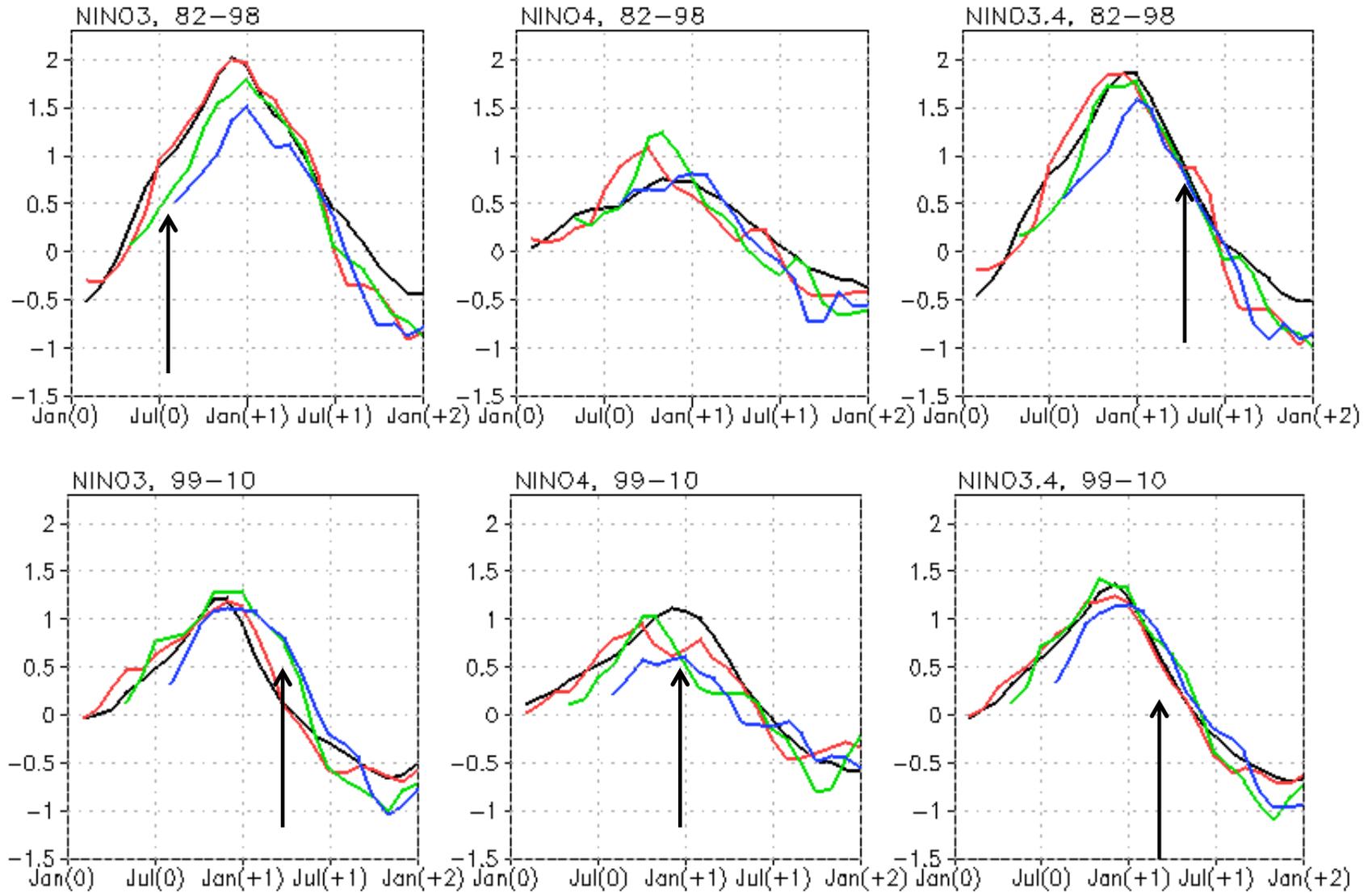
El Nino Composite

(Black=OBS,

Red=0-mon-L,

Green=3-mon-L,

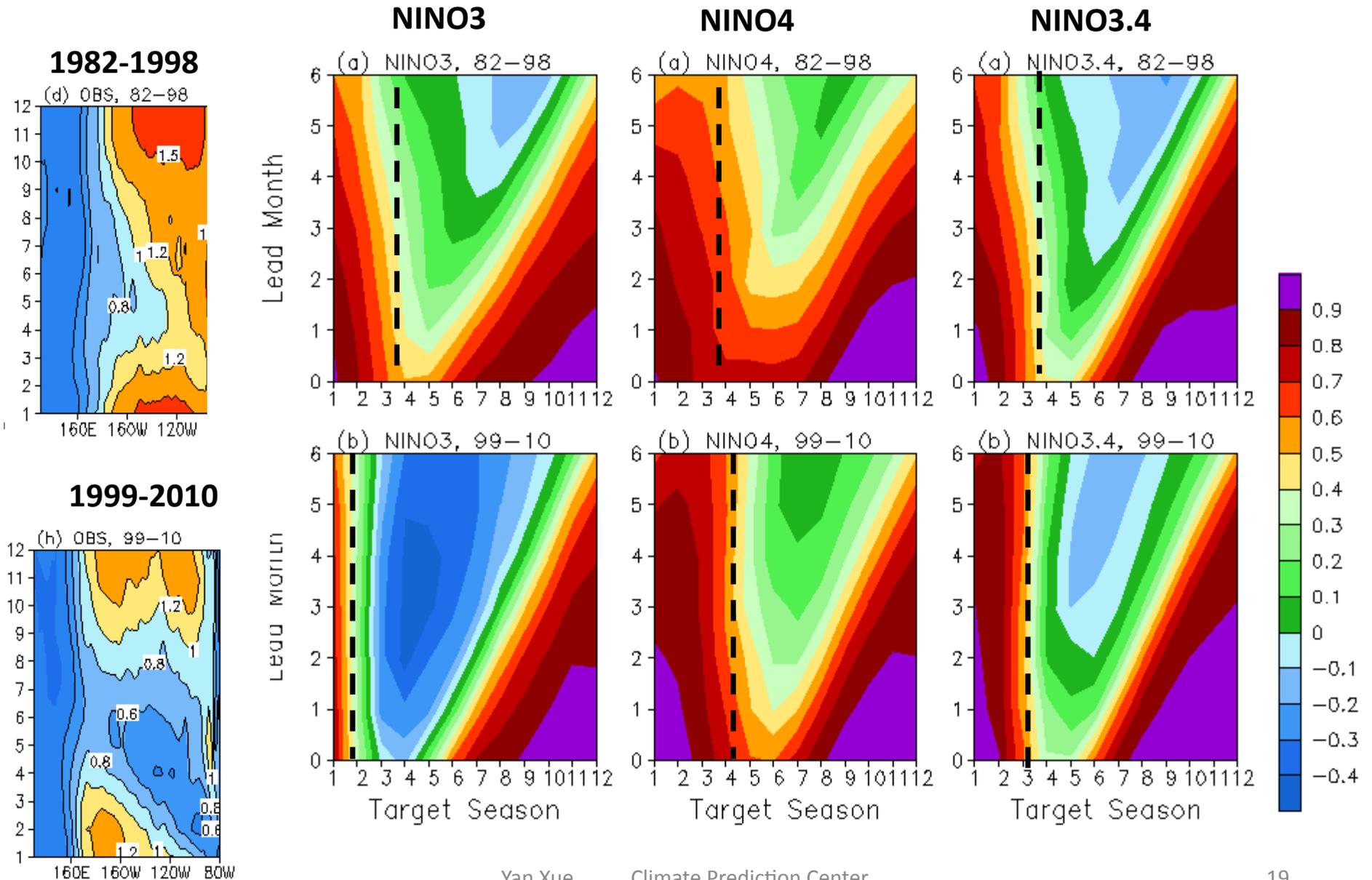
Blue=6-mon-L)



Summary

- **CFSv2 has a systematic cold bias near the Eq. that is largest (- 2.5°C) during summer/fall before 1999**
- **The equatorial cold bias weakened by more than 1°C from 1982-1998 to 1999-2010, related to a sudden increase in subsurface temperature in E. Pacific in CFSR when ATOVS satellite observations were assimilated in late 1998**
- **STD of SST is simulated well in 1982-1998, but is overestimated (underestimated) in E. Pacific (W. Pacific) in 1999-2010**
- **Deterministic skill suggests that CFSv2 has a higher skill in 1982-1998 than in 1999-2010, probably related to weakened variability in the later period and model's failure in capturing the changes in variability.**
- **CFSv2 has a weak "spring predictability barrier" in 1982-1998, but a strong "spring predictability barrier" in 1999-2010, related to changes in variability in the two periods**
- **RMSE in NINO3.4 generally agrees with model's ensemble spread, indicating that the model has a realistic ENSO instability mechanism**

Anomaly Correlation of Persistence SST



SST Forecast Bias in 2S-2N

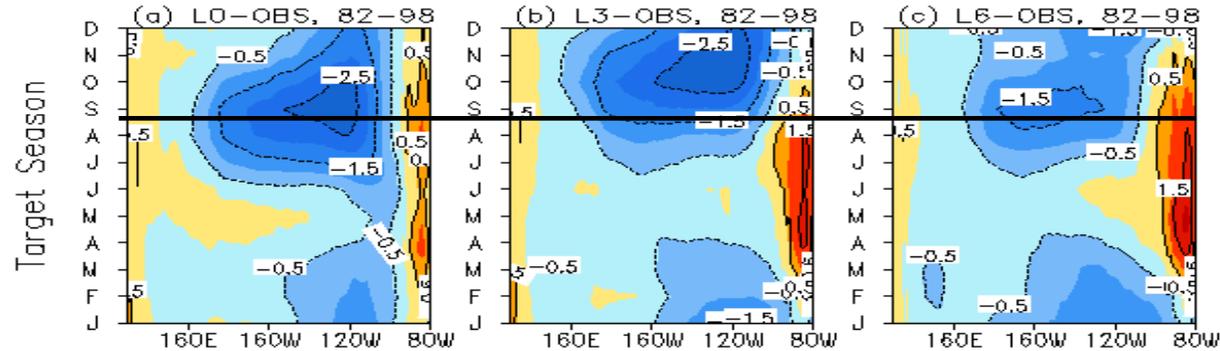
0-mon-L

3-mon-L

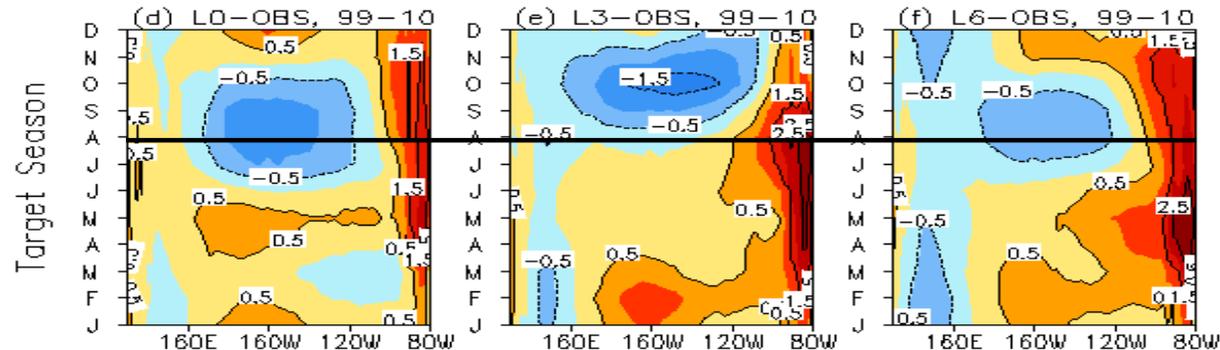
6-mon-L

SST Bias in [2S-2N]

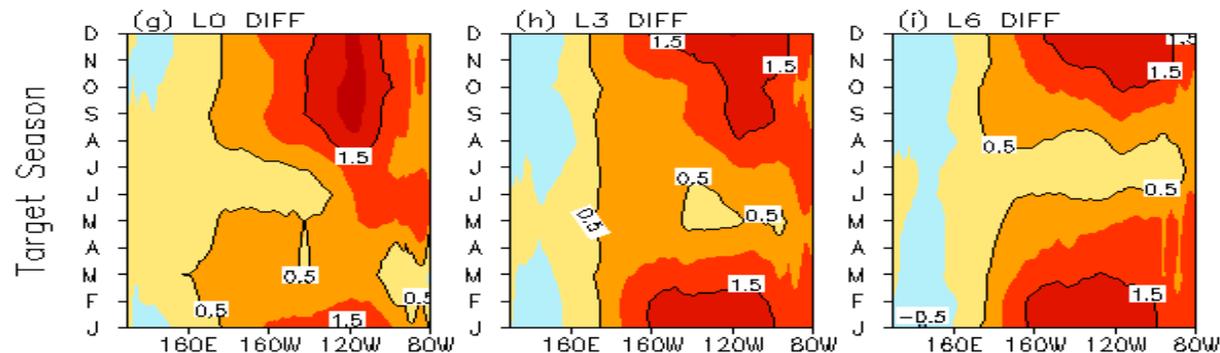
1982-1998



1999-2010



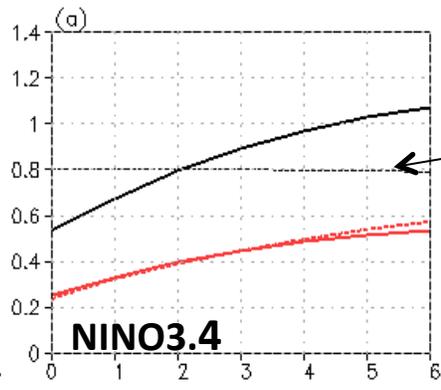
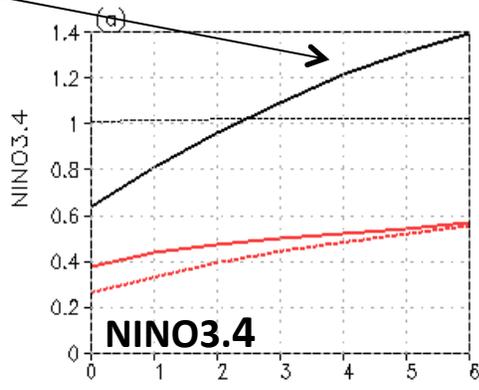
1999-2010 minus
1982-1998



Persistence RMSE

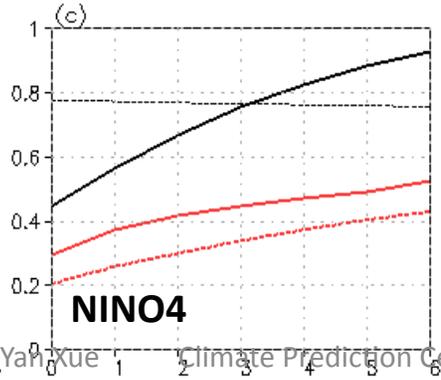
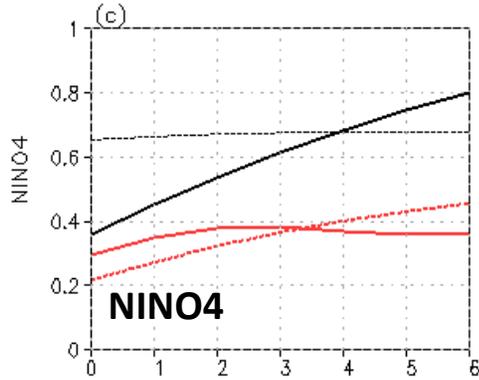
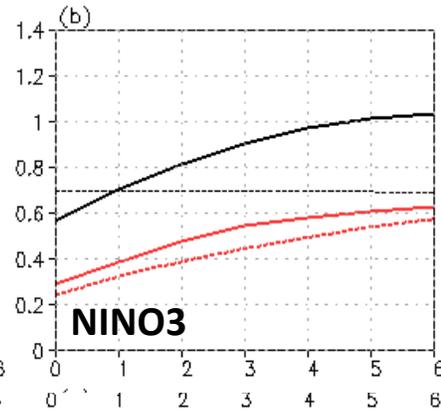
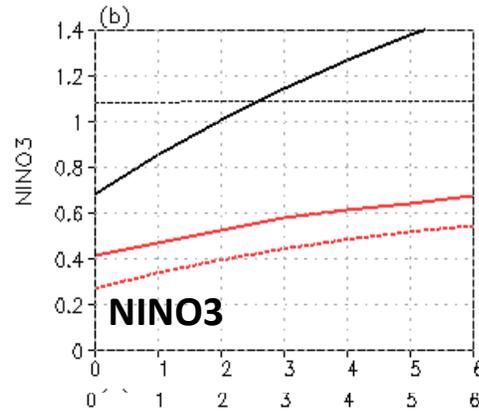
82-98

99-10



STD of Obs

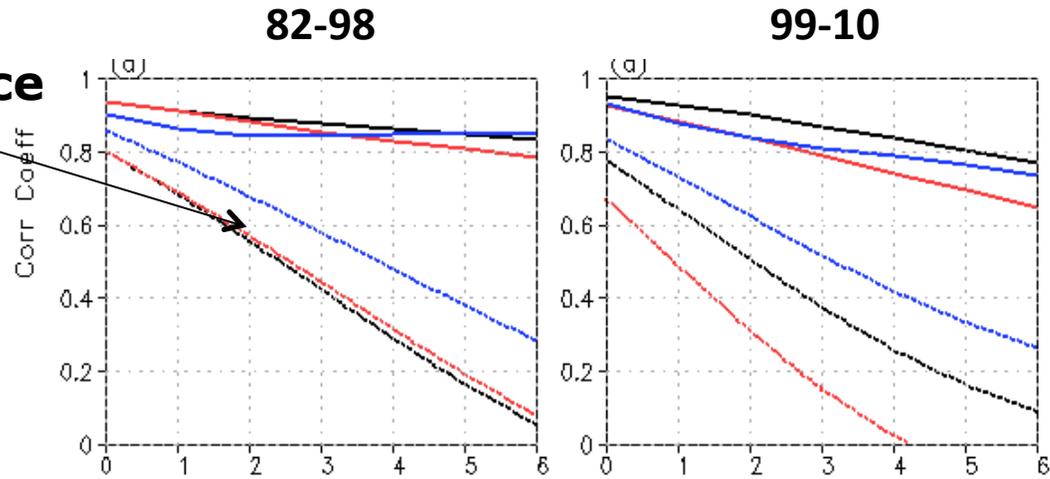
CFSv2 RMSE (solid)
CFSv2 spread (dash)



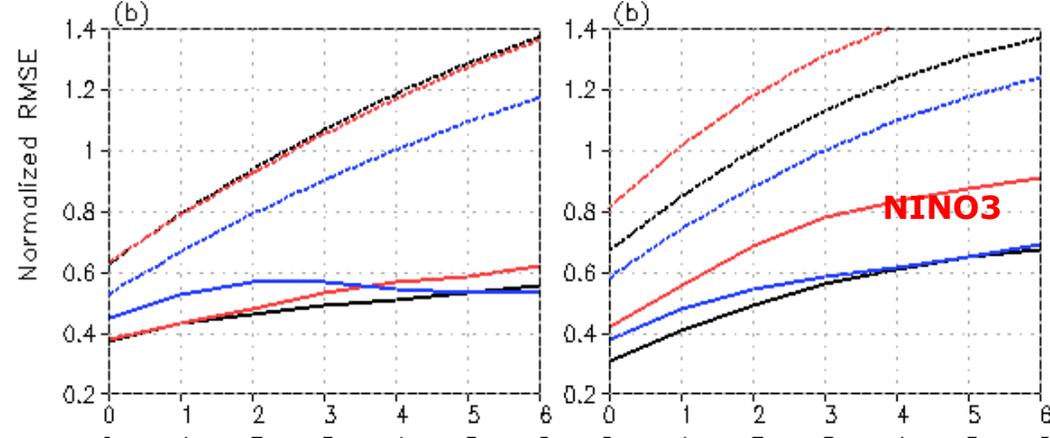
NINO3.4
NINO3
NINO4

persistence

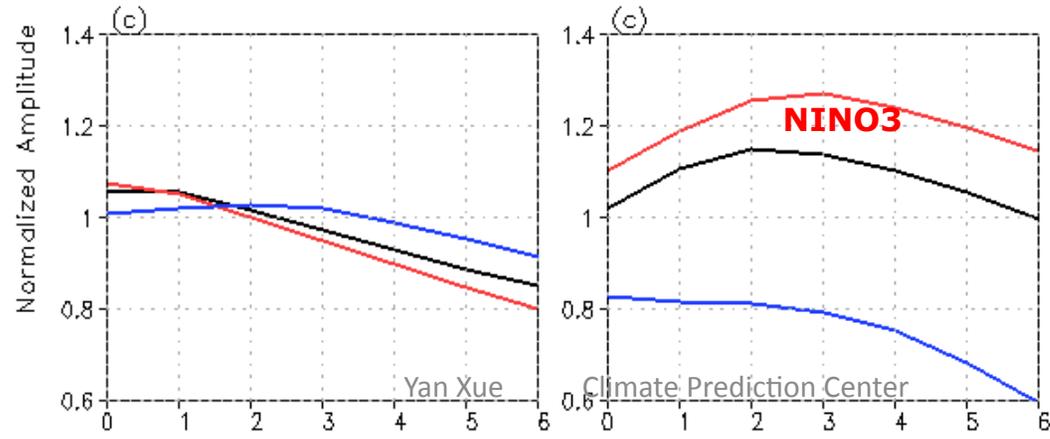
**Anomaly
Corr.**



**Normalized
RMSE**

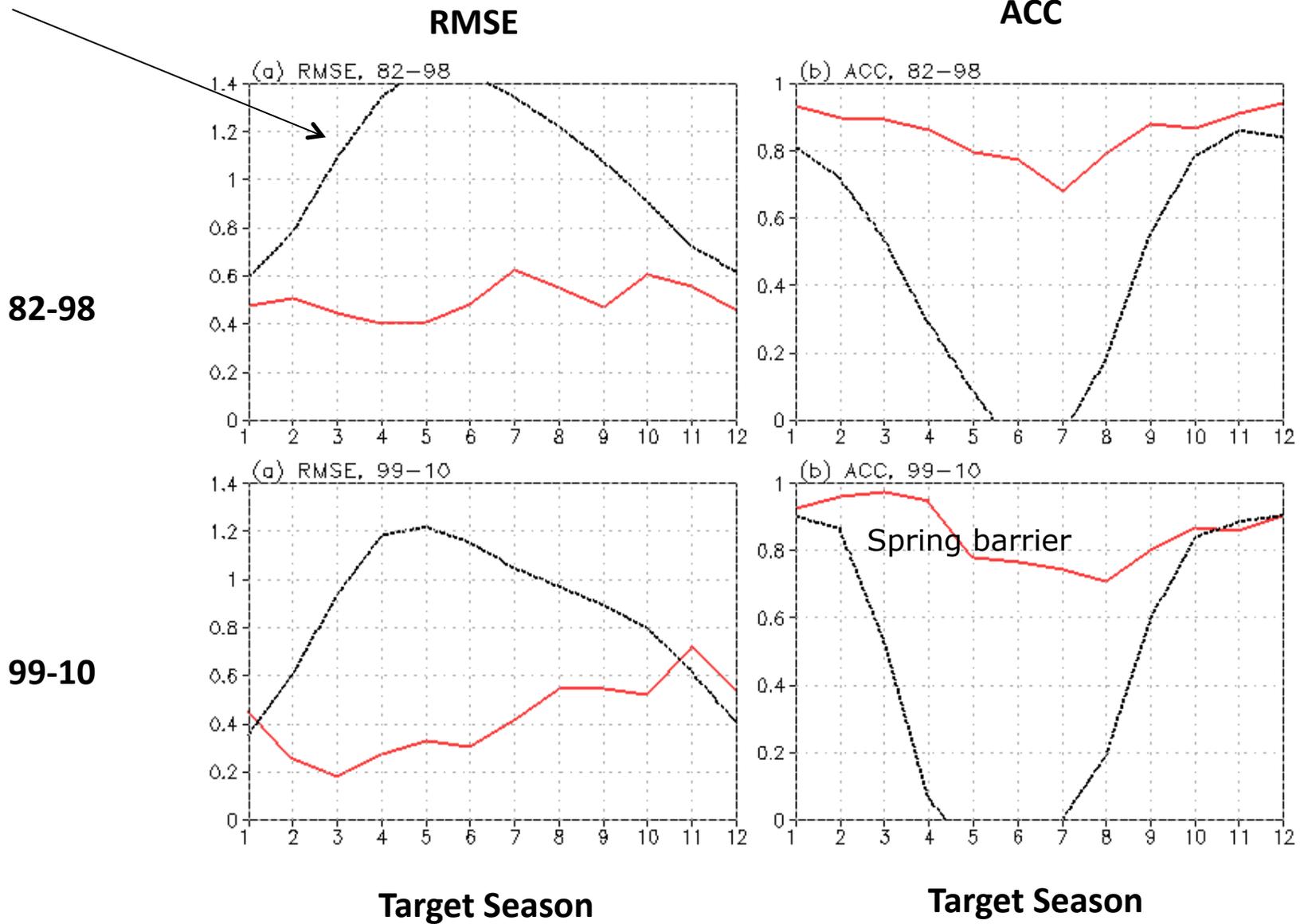


**Normalized
Amplitude**



NINO3.4 at 3-mon-L

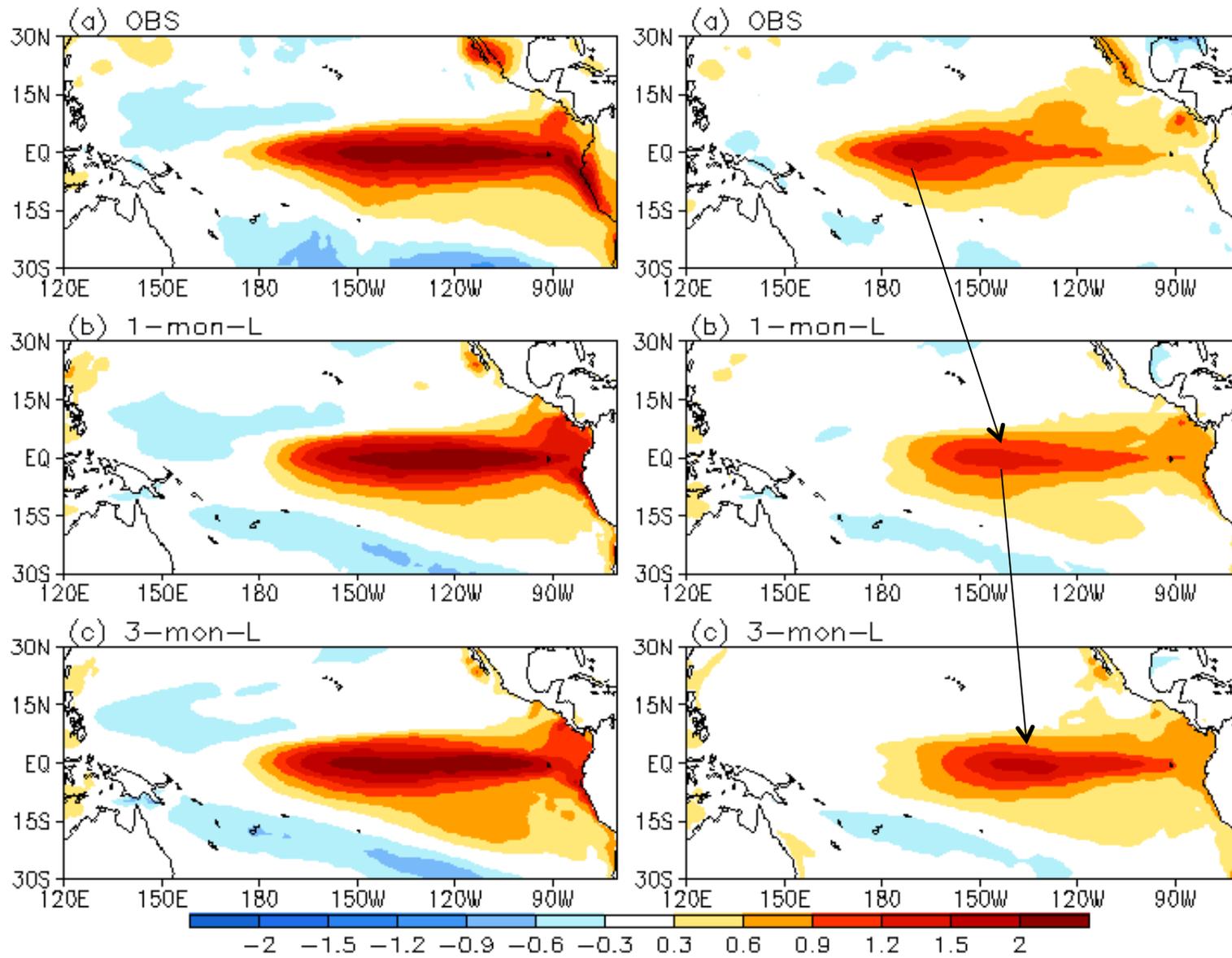
persistence

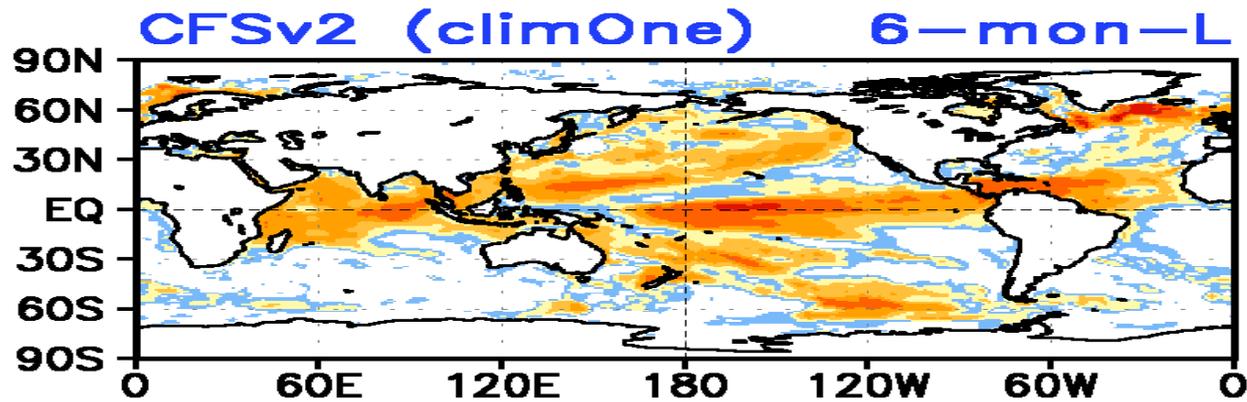


Eastern Pacific El Nino
(82, 86, 91, 97, 06)

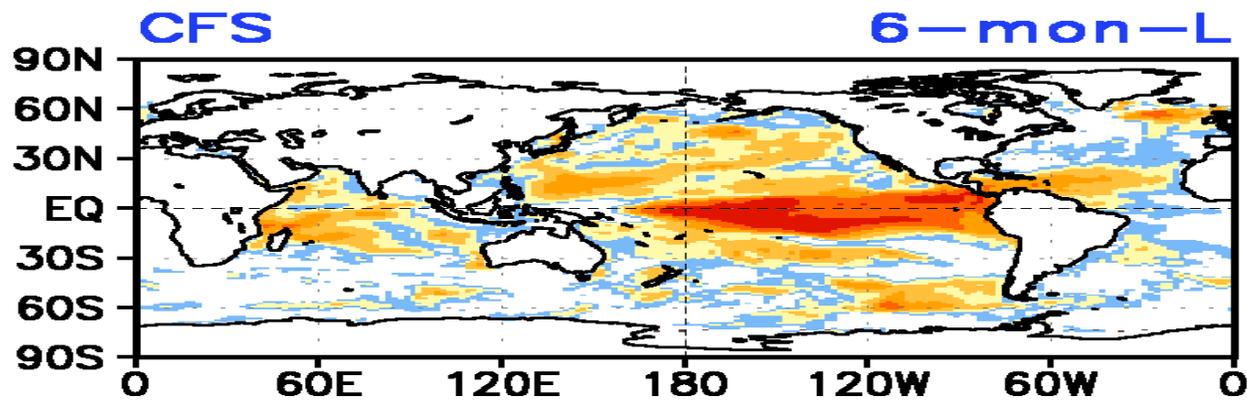
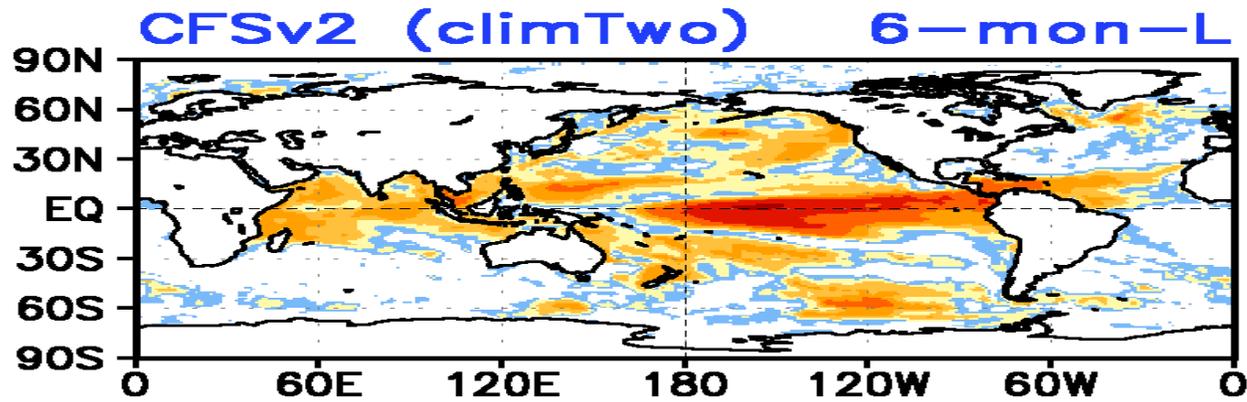
DJF

Central Pacific El Nino
(87, 94, 02, 04, 09)





Anomaly
Correlation – SST



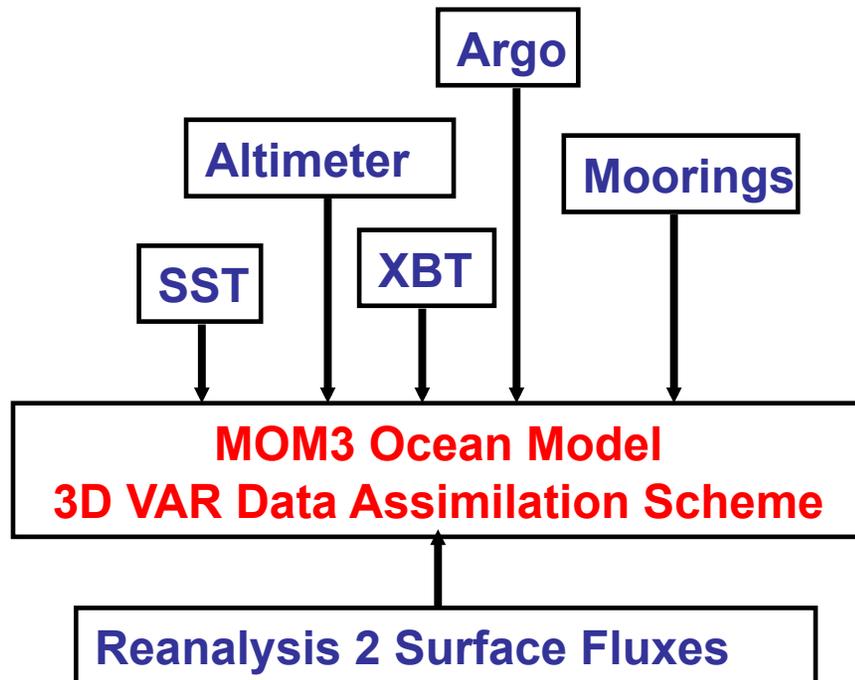
CFSv1 Ocean I.C.



CFSv2 Ocean I.C.

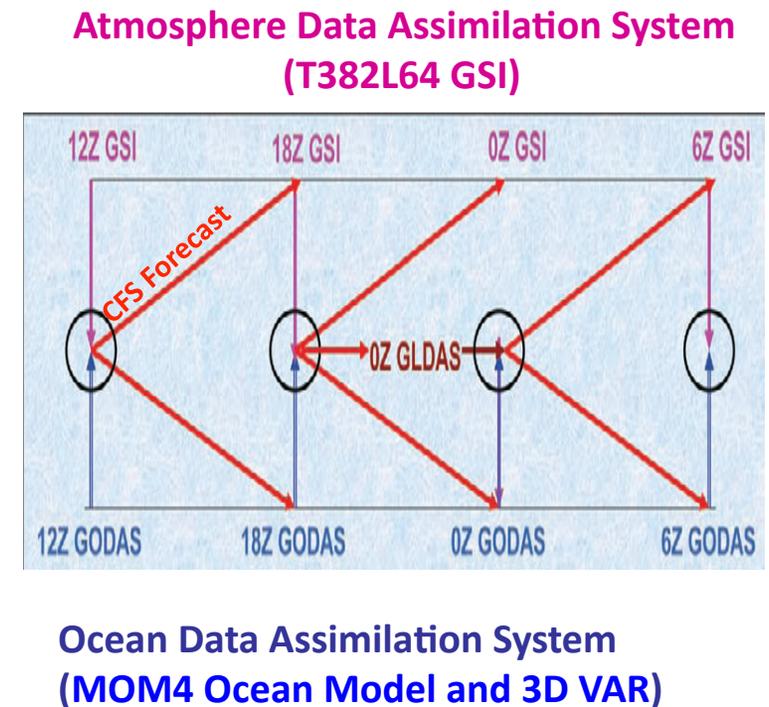
Ocean-alone

Global Ocean Data Assimilation System
(**GODAS**, implemented in **2003**)

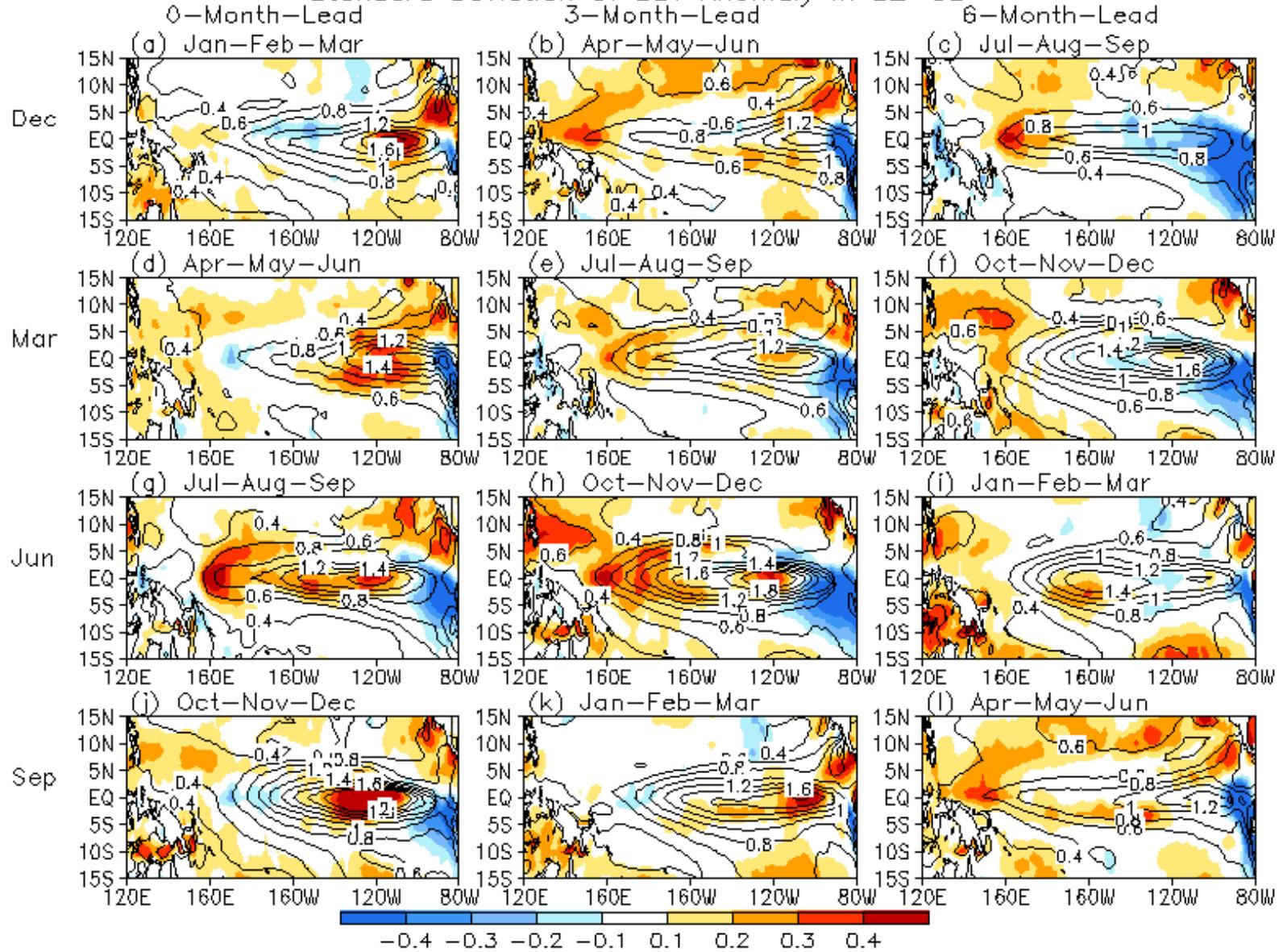


Partially Coupled System

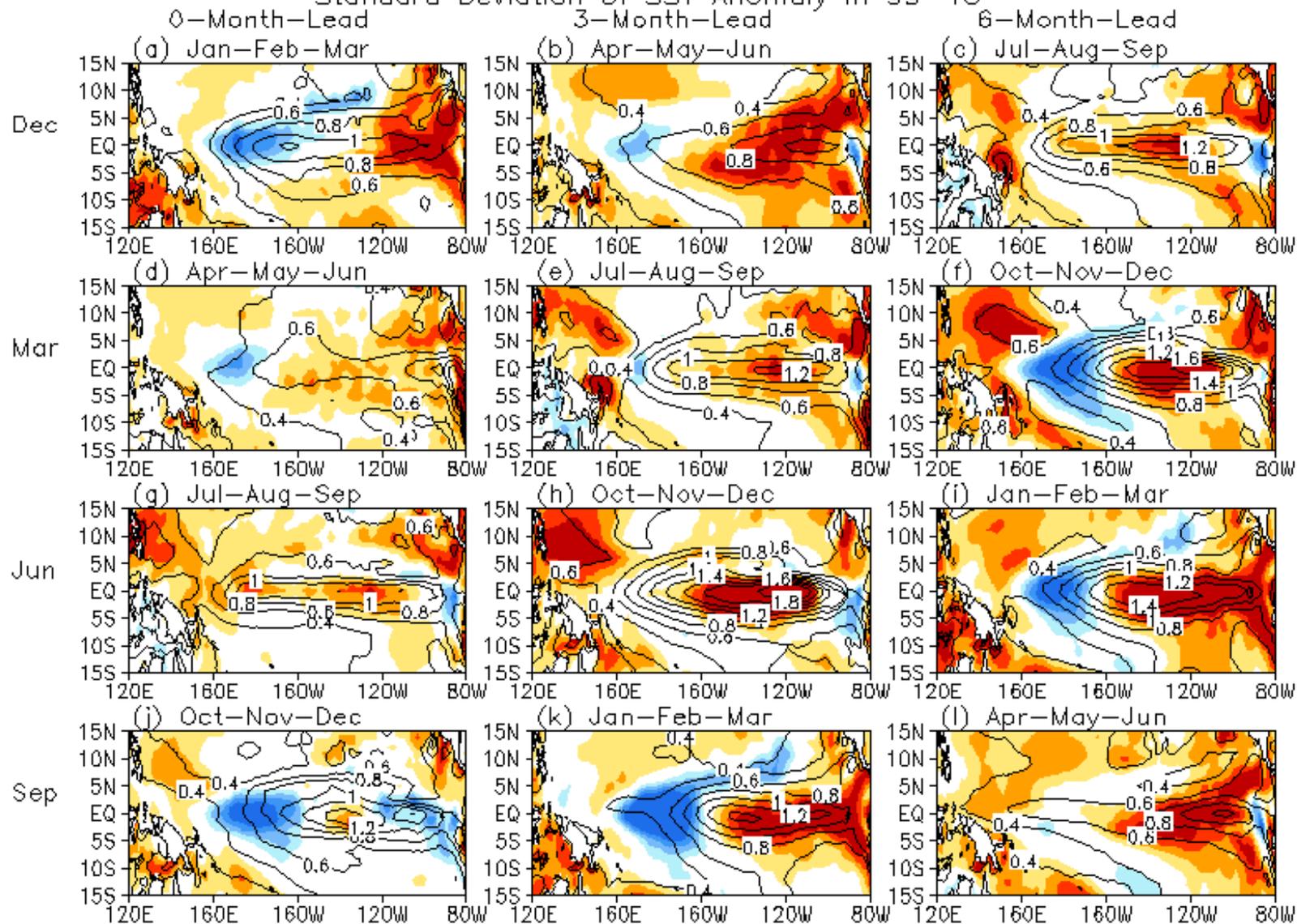
Climate Forecast System Reanalysis
(**CFSR**, implemented in **2011**)



Standard Deviation of SST Anomaly in 82-98

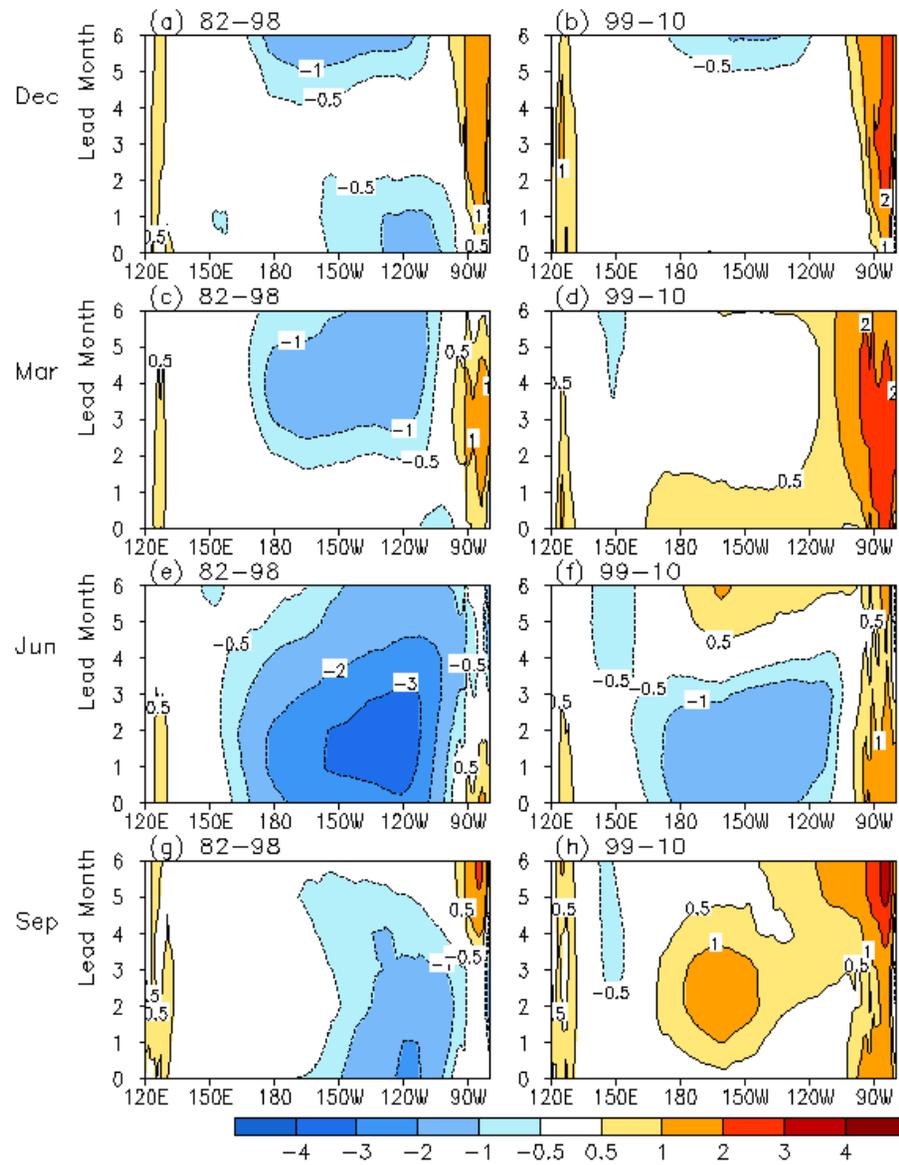


Standard Deviation of SST Anomaly in 99-10

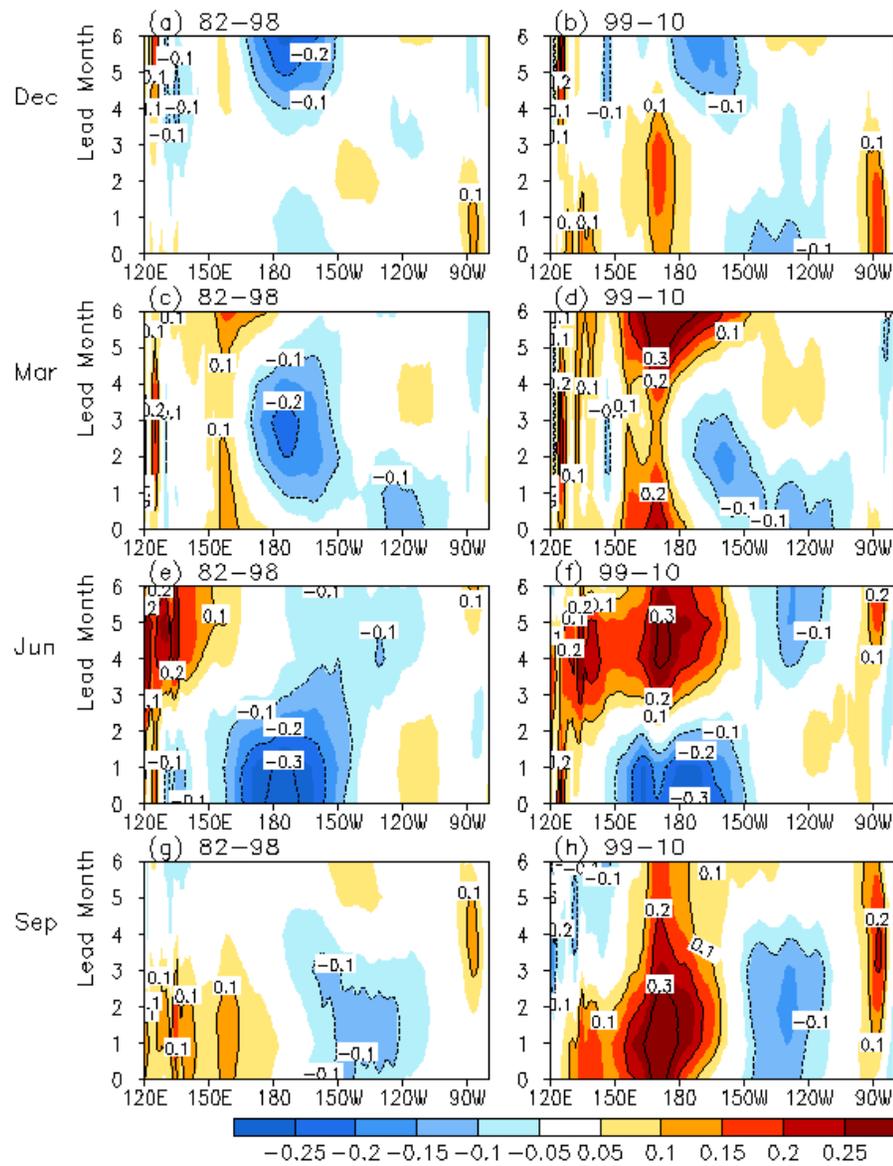


Yan Xue Climate Prediction Center

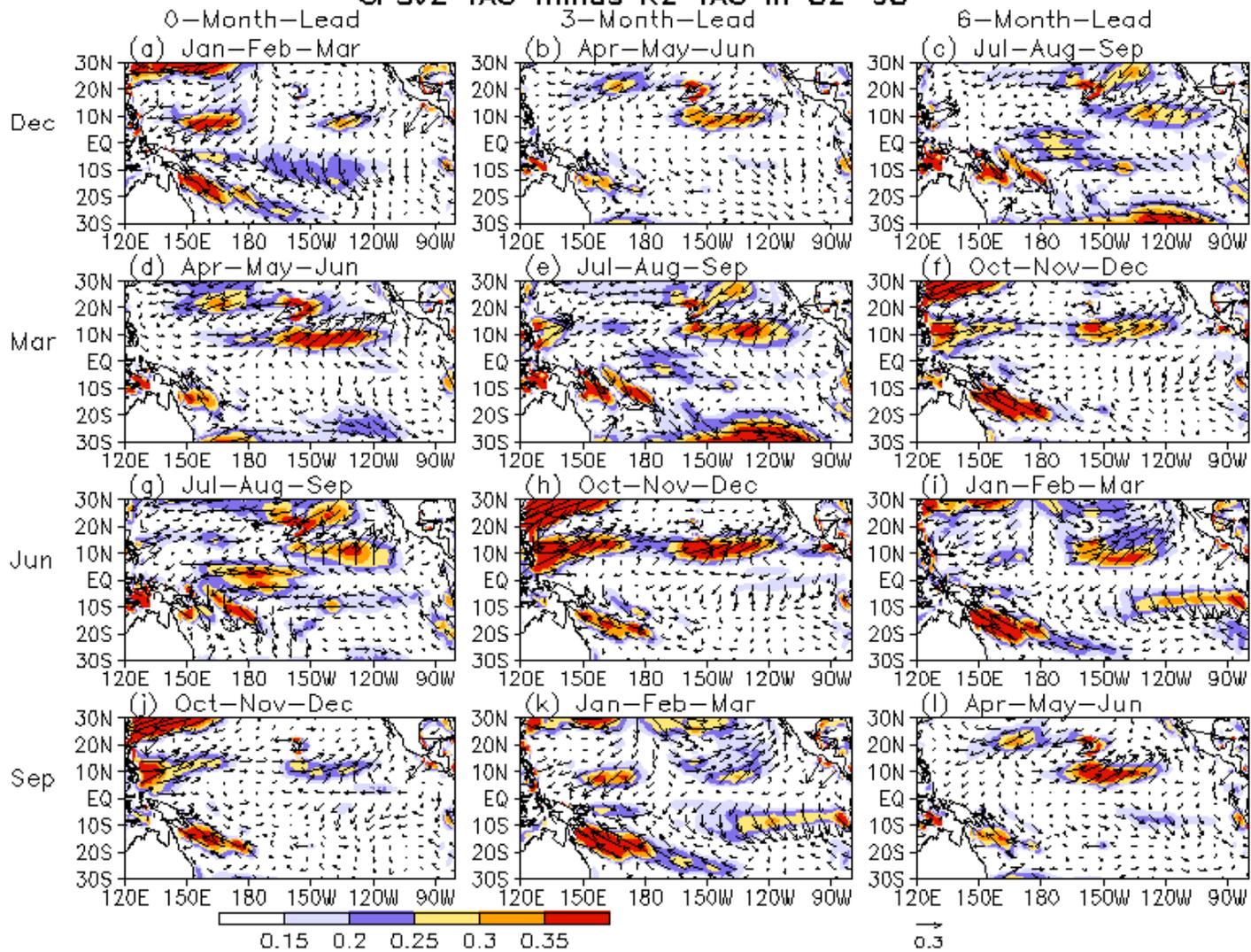
SST Bias in 1S-1N (degree)



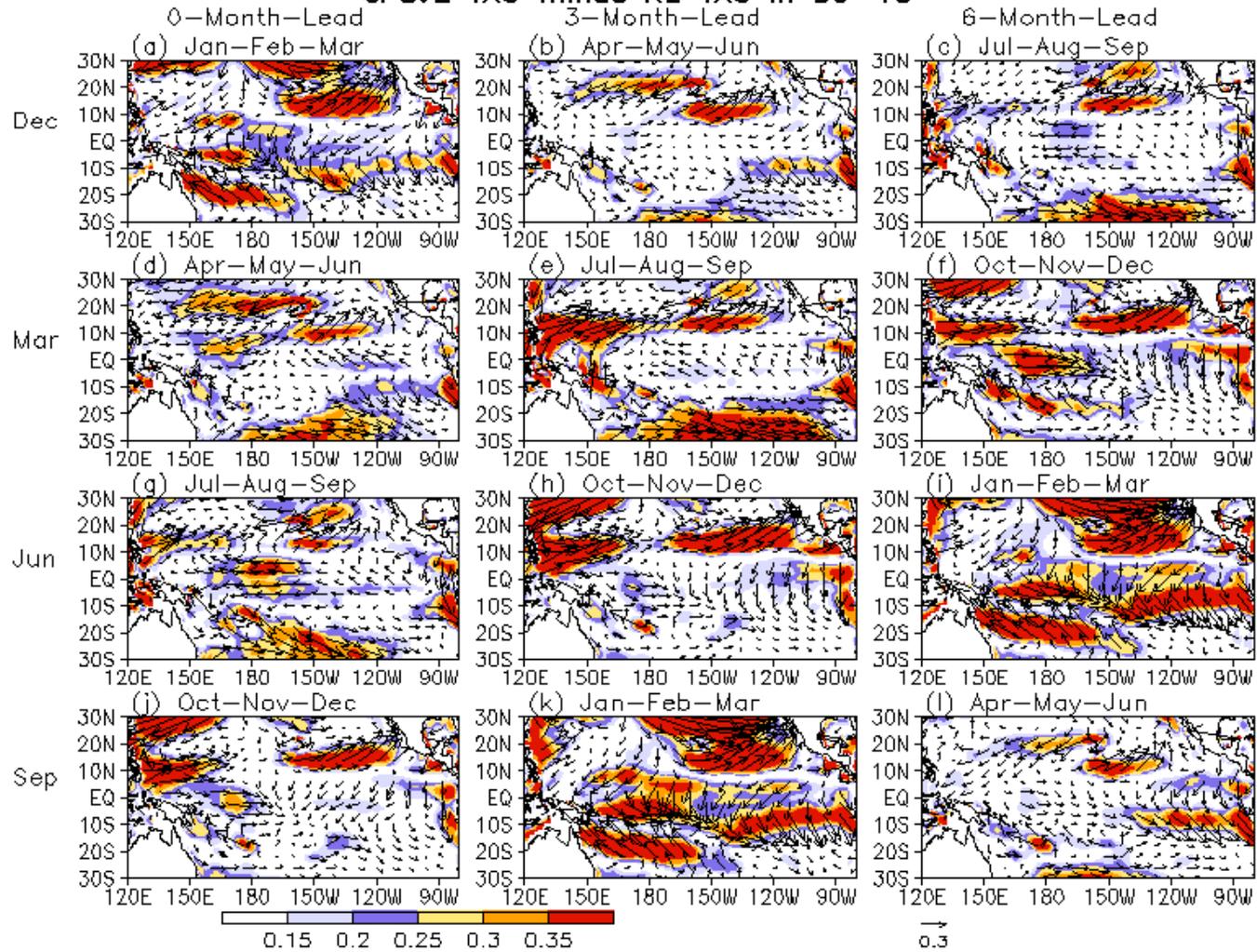
TAUX Bias in 1S-1N (dyn/cm**2)



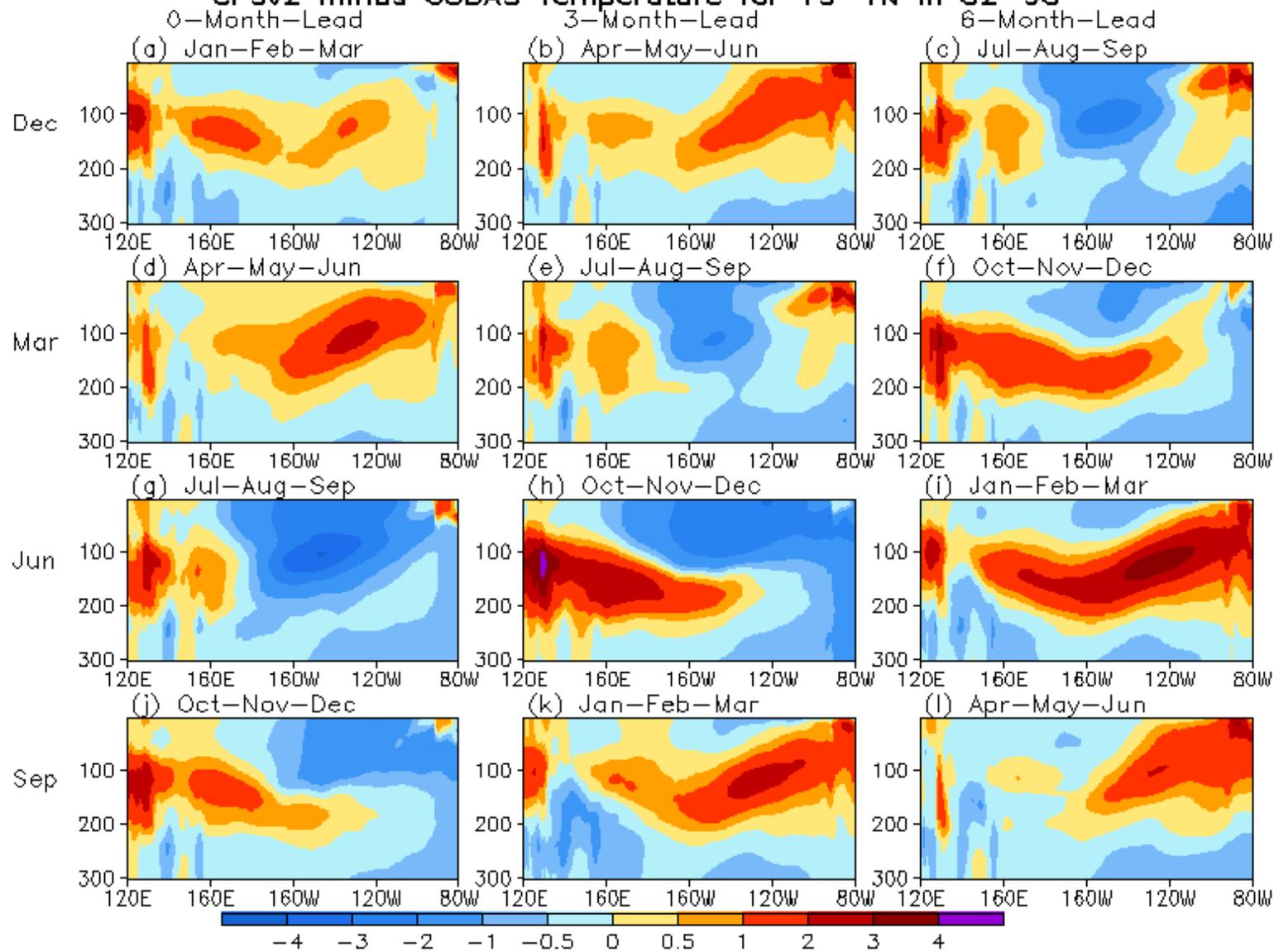
CFSv2 TAU minus R2 TAU in 82-98



CFSv2 TAU minus R2 TAU in 99-10



CFSv2 minus GODAS Temperature for 1S-1N in 82-98



Yan Xue Climate Prediction Center

CFSv2 minus GODAS Temperature for 1S-1N in 99-10

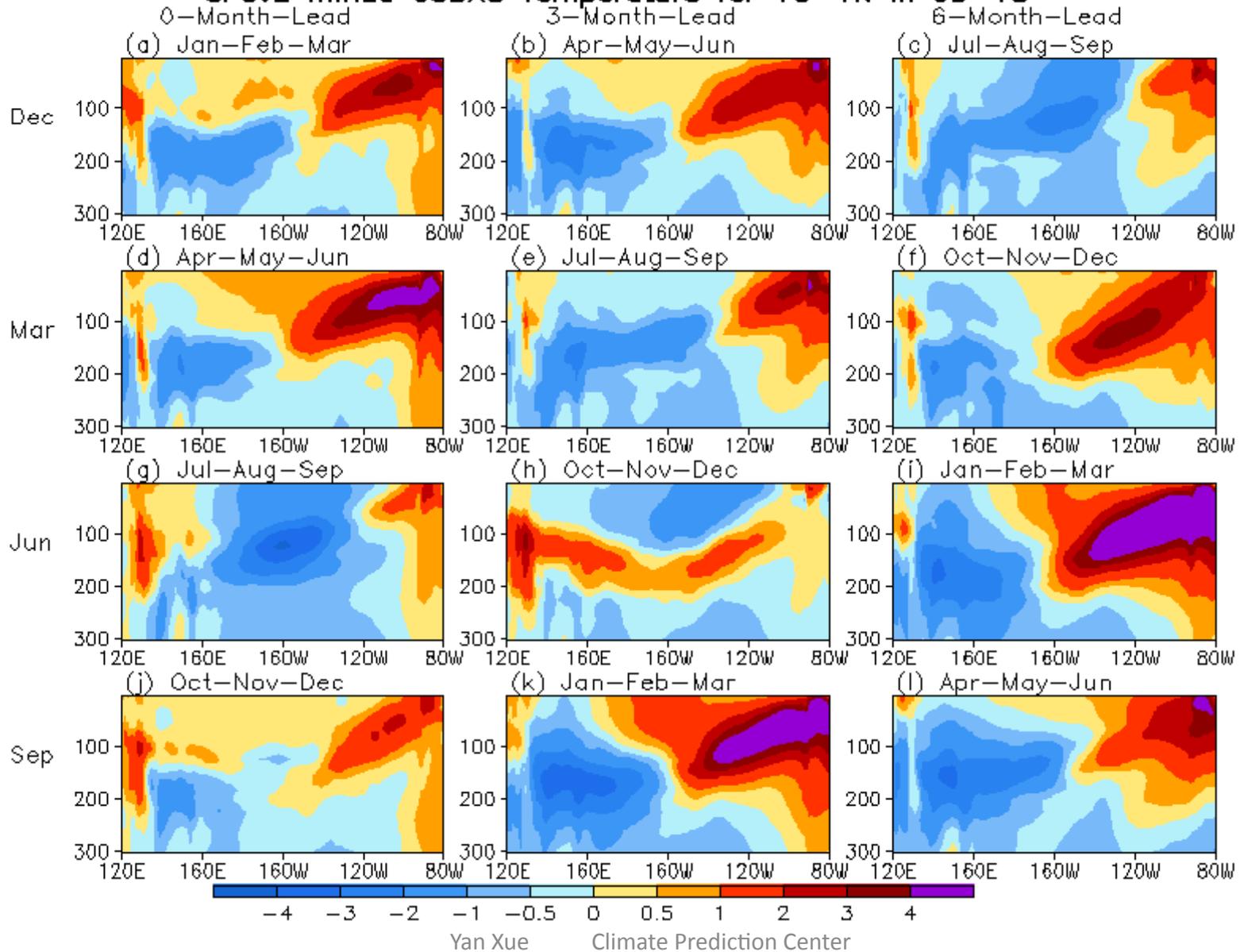


Fig. 5 (Yan)

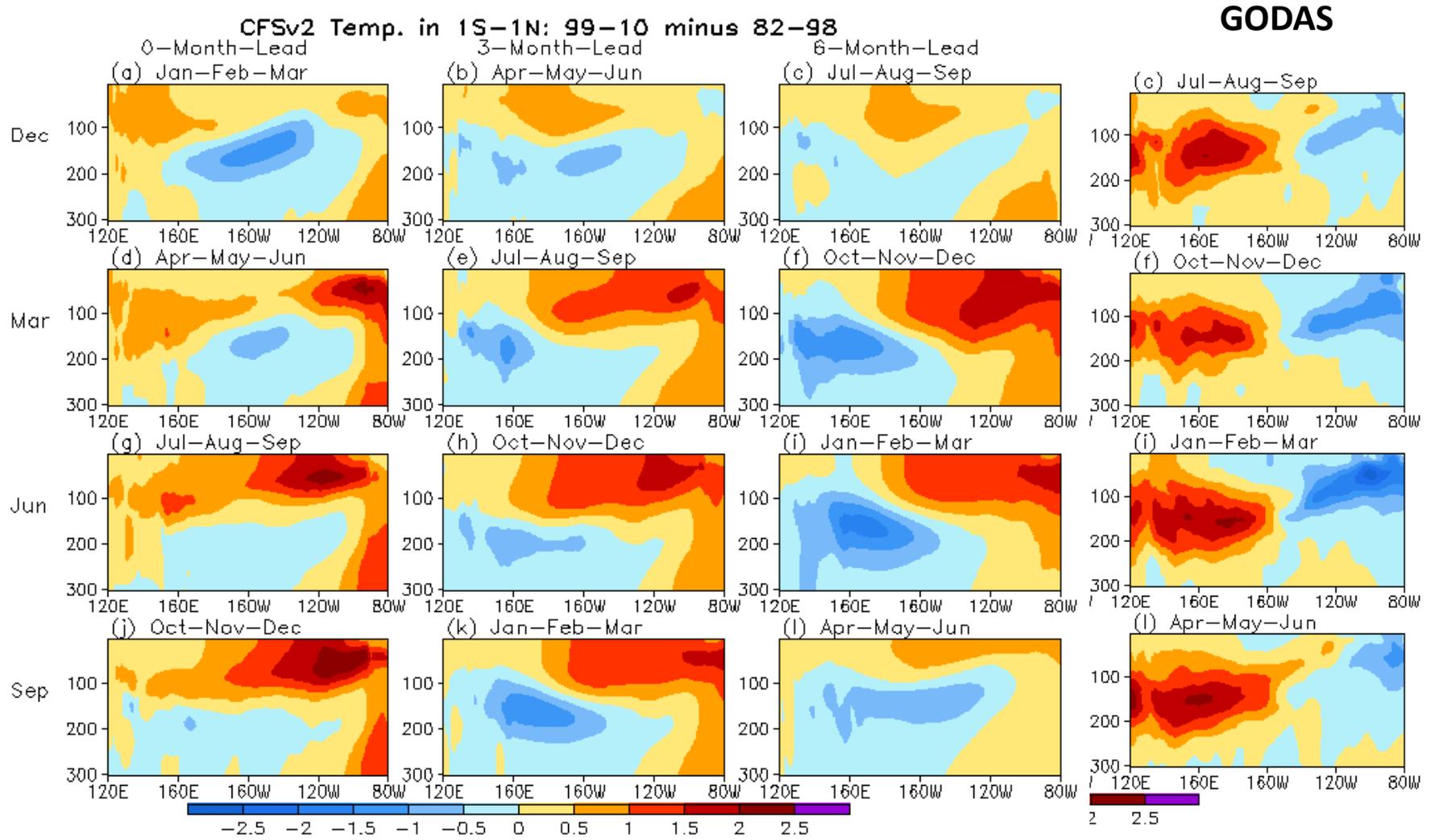


Fig. 4 (Yan)

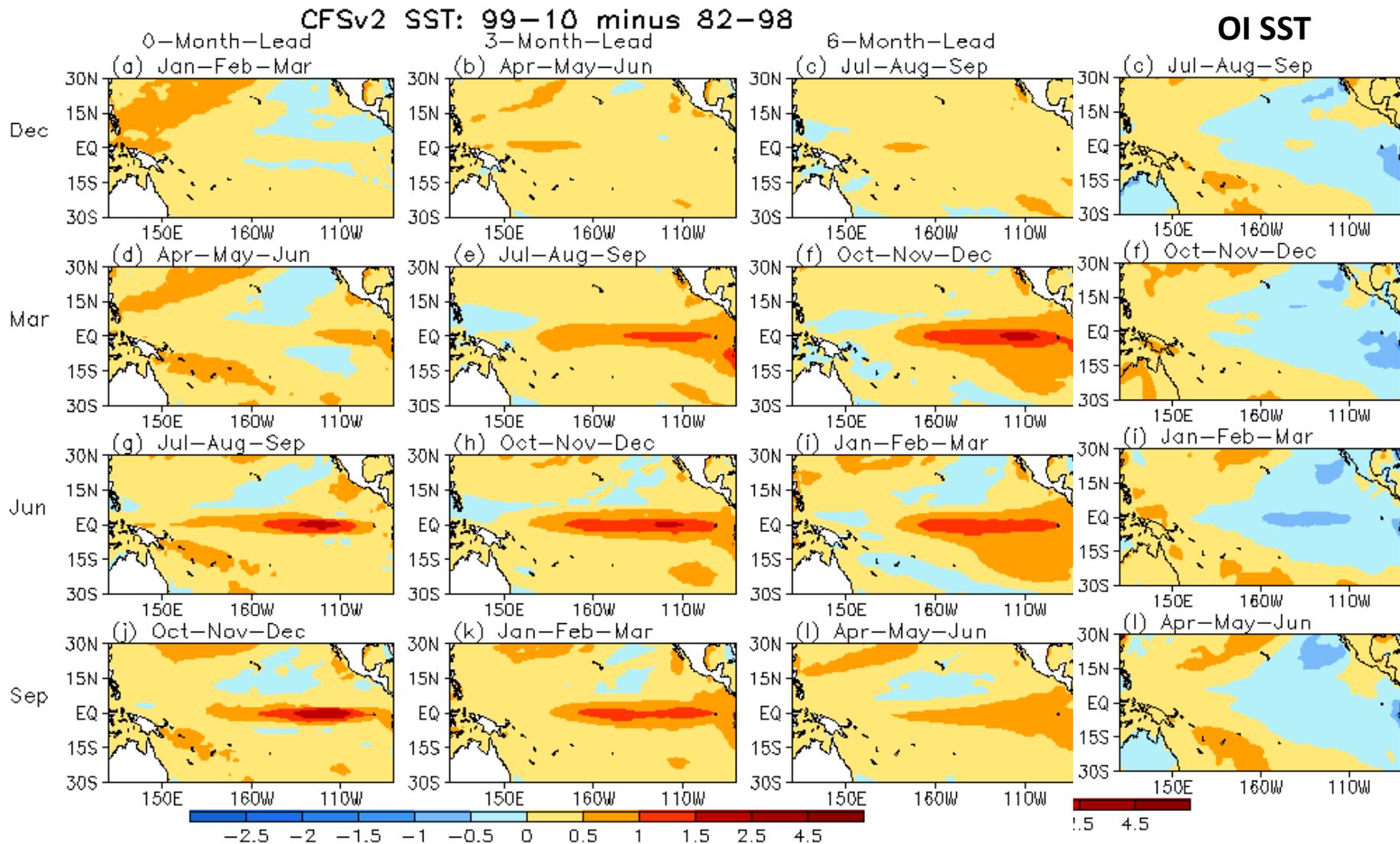


Fig. 8 (Yan)

